

The Vegetation History of the Holocene at Dry Lake, Thirlmere, New South Wales

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At the beginning of the Holocene, Dry Lake was a lake, with a fringe of cyperaceous reeds. *Eucalyptus* and *Allocasuarina* were the dominant trees and Asteraceae Tubuliflorae were prominent in the understorey. Between 8 ka and 2 ka, the lake became shallower, and the reeds grew over the surface of the developing swamp, forming peat. An hiatus in peat deposition between 5 ka and 2ka was followed by the formation of a thin layer of diatomite. Eutrophic conditions would be required to allow large populations of diatoms and burning seems the most likely way of increasing the nutrient mobility on the poor sandstone soils of the catchment.

By 2 ka, the lake had become a peat swamp. *Angophora/Corymbia* pollen had increased dramatically, most likely representing *Angophora* on these alluvial flats. The shrub layer had also become more diverse. *Allocasuarina* did not decrease through the Holocene, unlike the record of many other Holocene sites. The likely reasons for this difference are probably related to site-specific environmental conditions. With European settlement, all trees decreased dramatically and grasses increased. Today, Dry Lake only contains water in exceptionally wet periods.

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INTRODUCTION

Dry Lake is one of a series of freshwater lakes associated with an incised former river valley at Thirlmere. The Thirlmere Lakes are rare examples of very old, small lakes that have aged very slowly as a result of the stable geological nature and small size of the catchment (Horsfall et al., 1988). The initial development of the lakes was related to tectonic activity associated with the formation of the Lapstone Monocline, Kurrajong and Nepean Faults which beheaded a river that probably originally flowed westwards, leaving the isolated, sinuous channel that now contains the lakes (Timms, 1992). At this time, or sometime later, the drainage direction changed and today Dry lake drains in a north-easterly direction along Cedar Creek and the Thirlmere Lakes drain westwards along Blue Gum Creek (Fig. 1). Presently, Dry Lake only contains water intermittently in wet years, when the water depth approximates 60 cm.

The basal sediments of Dry Lake have been radiocarbon dated at about 10,000 years before

present which approximates the beginning of the Holocene when the climate had mainly recovered from the peak of the glacial period but there was a lag in the recovery of the vegetation. The Holocene thus records the establishment of the present vegetation. *Allocasuarina/Casuarina* was usually more prominent following the last glacial period but during the Holocene, it declined and *Eucalyptus/Corymbia* rose to dominance (Clarke, 1983).

This paper presents the Holocene history of the vegetation at Dry Lake and compares it with Lake Baraba, one of the Thirlmere Lakes (Black et al., in press), some 4 km to the south.

THE ENVIRONMENT

The former river valley that includes Dry Lake is incised in Hawkesbury Sandstone, but the surrounding higher plateau surfaces retain cappings of Ashfield Shale, the lower member of the Wianamatta Group, which overlies the Hawkesbury Sandstone. Both

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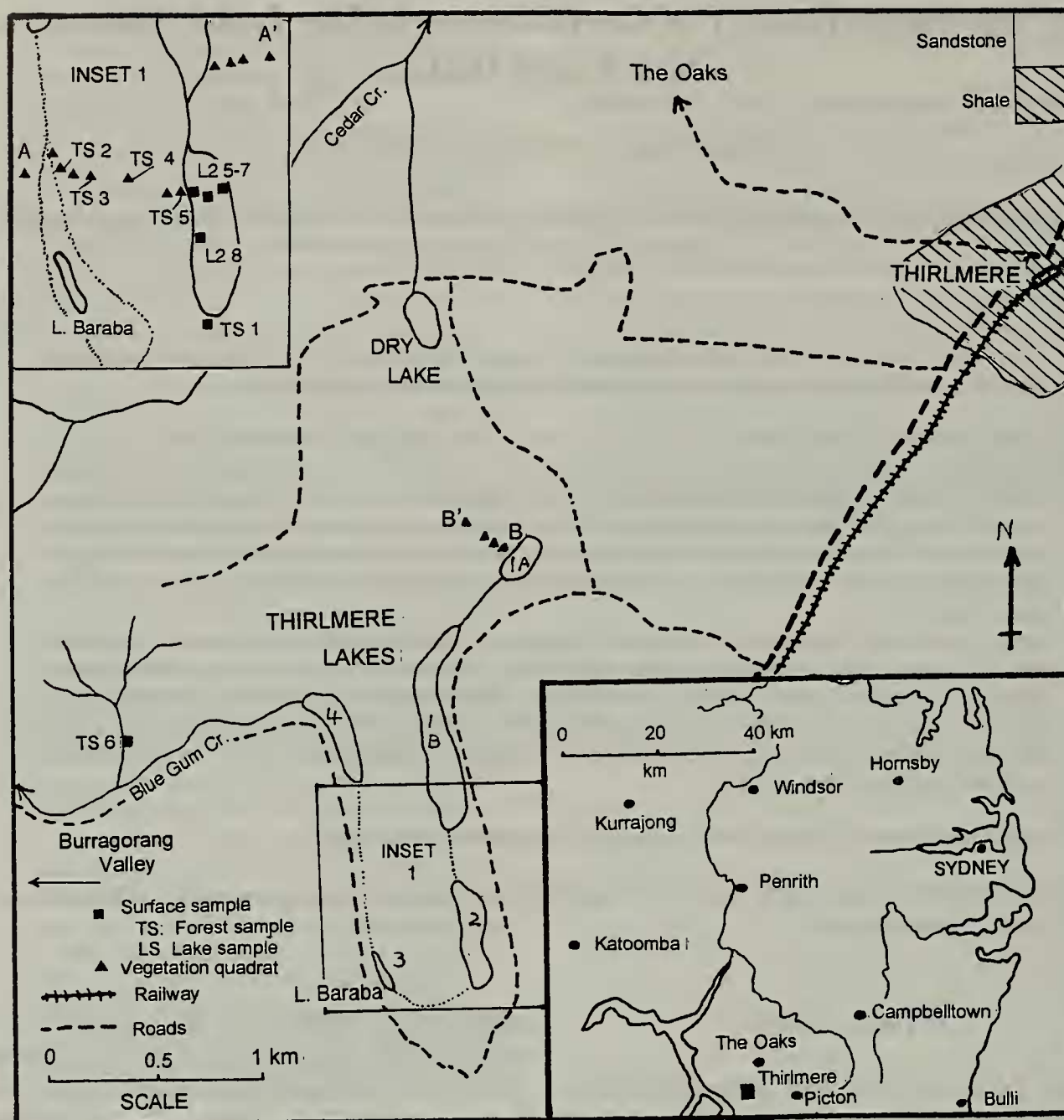


Figure 1. Locality map.

formations are of Triassic age (Herbert, 1980).

Although Hawkesbury Sandstone dominates the landforms and soils occurring in the study area, there is a shale outcrop on the ridge to the east of Dry Lake (Fig. 1). This may be either the Ashfield Shale or a shale lens in the sandstone, as it is very close to the contact between the two formations. The soils developed on the sandstone are uniform sandy loams with some organic staining in the upper horizons. They are acid, of low nutrient status and low water retaining capacity, and vary in depth and drainage, depending on the topography.

Thirlmere has warm to hot summers and cool to mild winters (Bureau of Meteorology website, BoM, 2005). The average annual rainfall of the nearest

station, Picton, is 820 mm and it is received in two relatively wet periods from January to March and in June. The median rainfall for each month is greater than 25 mm (BoM, 2005). There is considerable variation in rainfall and after long dry spells, the Thirlmere Lakes dry out. Known dry lake stages occurred about 1902, 1929 and 1940 (Rose, 1981).

The Thirlmere Lakes were first sighted by Europeans in 1798. By 1833, many settlers had arrived at the Oaks, north of Thirlmere, and mixed farming flourished. Timber cutters logged mostly *Eucalyptus deanei*, especially along Blue Gum Creek (Woods, 1980). Most of these activities were more intense on the better soils of the shale areas and on the alluvial flats. Present land uses consists of residential

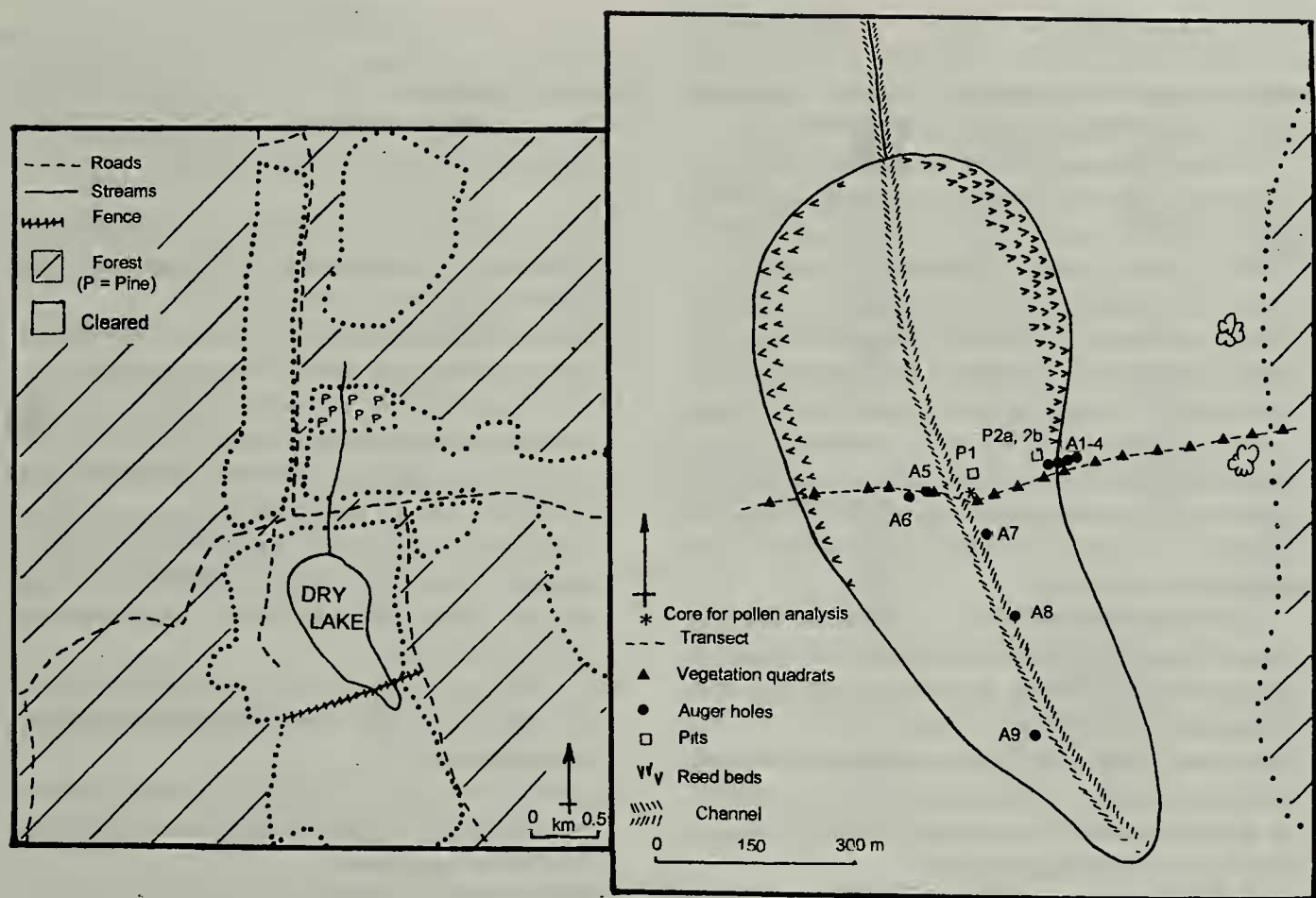


Figure 2. Dry Lake and environs.

housing and small farms.

Four main vegetation units described by Pidgeon (1937; 1941) apply to this area and they are: 1), the *Eucalyptus deanei* and *Eucalyptus elata* tall open forest in the gullies; 2), the Mixed *Eucalyptus* Association of the ridges and slopes; 3), the *Angophora floribunda*/*Melaleuca linariifolia* forest of the alluvial fans and 4), the aquatic vegetation of swamps and lakes. The mixed *Eucalyptus* Forest Association constitutes the major part of this study area. The National Park was completely burnt in 1955 and has suffered considerable damage from local fires since then (R. Kintish, pers. comm.). Dry Lake has been cleared of native vegetation and is predominantly a grassland but it is assumed that the native vegetation would have been much the same as that in the surrounding areas.

METHODS

Field work was carried out during 1981 when the vegetation survey was undertaken. (Appendix 1). Quantitative data on plant distributions were obtained

from quadrats along transects (Rose, 1981). The vegetation map was prepared using aerial photographs and the field survey (Figs 1, 2).

The stratigraphy of Dry Lake sediments was investigated by auger holes and two pits (Fig. 2) which were limited to a depth of 1.5 m by heavy clay. A core, located near the centre of the lake but where there was minimal disturbance and away from local pollen sources, was chosen for pollen analysis. This core was taken using a Hiller corer. Samples for radiocarbon dating were taken from the pits and analysed by the then Radiocarbon Laboratory of the University of New South Wales. All of the samples were stored in a 4°C cold room to suppress microbial growth until work could proceed.

Surface samples of soils, mosses and lake sediments were collected (Figs 1, 2) to study pollen deposition under the present vegetation and assist in the interpretation of pollen in the core. Lake surface sediments were sampled using a weighted cylinder on a line.

Sediment samples 2 cm in length and 3 cm apart were taken from Pit 1 for organic matter analysis. Duplicated samples were oven-dried (105°C) and

ignited in a muffle furnace to 500°C. During ignition, structurally bound water is lost, but in highly organic sediments, the major loss on ignition is from the organic matter (Bengtsson and Enell, 1990).

Pollen preparations from the sediment core were spiked with *Alnus* of a known concentration, treated with hydrofluoric acid to remove siliceous material, boiled in 10% sodium hydroxide to remove humic acids, disaggregated with ultrasonic vibration, followed by standard acetolysis (Moore et al., 1991). Surface samples were treated in the same way, with the addition of sieving to remove sand, leaves, twigs etc. and omitting the *Alnus* spike. Reference pollen used for identification was only treated with standard acetolysis. The residues were mounted in silicone oil (viscosity of 2,000 centistokes) or glycerine jelly, using grade 0 coverslips.

Siliceous fossils were recovered from a known volume of sediment using an acid sequence (hydrochloric, nitric and sulphuric acids) and then dehydrating the residue in absolute alcohol. The residue was made up to a known volume, and with constant agitation, a known aliquot was extracted, the alcohol allowed to evaporate and mounted in Napthrax in toluene (Lacey, 1963).

Pollen was identified by comparison with a reference collection using the x 1000 magnification objective. Where it was not possible to identify some grains, they are listed as unknowns. The pollen of members of the family Myrtaceae is similar and it requires a careful analysis of the finer morphological features to separate them (Chalson and Martin, 1995). In this study, three groups were distinguished: *Angophora/Corymbia*, *Eucalyptus* and *Melaleuca/Leptospermum* (Appendix 2). The name on the pollen diagram and probable source in the vegetation is listed in Appendix 3.

Pollen was counted using the x 400 objective of a Zeiss microscope. Tests to assure an adequate count showed 160-200 grains was sufficient. Some samples had insufficient pollen for an adequate count, and this is indicated on the pollen diagram.

Counts were made of sponge spicules on a Zeiss microscope, using the x 250 and x 400 objectives. Only one species of sponge was present and the spicules consisted of megascleres, gemmoscleres and fragments of both. Three quarters of a sclere was counted as a whole sclere and more than one quarter as a fragment. Counts were made along transects spaced evenly across the slide to ensure a representative count. Knowing the ratio of the area counted to total area of the slide, and the volume of the aliquot to total volume of residue, the counts were converted to numbers of scleres per volume of sediment.

RESULTS

The Lake Sediments.

The sequence of sediments in the central part of Dry Lake is as follows, from top to bottom (Fig. 3):

- 1) A layer of little decomposed fibrous peat, composed of rhizomes, root and stems of cyperaceous reeds (probably *Lepironia articulata*).
- 2) Well humified black clayey peat with abundant roots, rhizomes and seeds of cyperaceous reeds.
- 3) A fine sandy clay, yellowish in colour and with sharp upper and lower boundaries. When dry, this material was light and powdery. This description resembled that of diatomite (Birks and Birks, 1980) and microscopic examination showed it consisted almost entirely of siliceous sponge spicules, diatoms and sand grains. Organic content was minimal.
- 4) A sandy peaty clay may or may not be present, was usually less than 3 cm thick and had a diffuse lower boundary.
- 5) A black clay layer with light to medium texture appeared highly organic. Boundaries between all clay layers were diffuse.
- 6) This medium textured clay formed the bulk of the sediment sequence. It was a greyish brown colour, with frequent yellowish-red mottles. At certain depths, red (iron) streaks or small iron stained clay concretions (< 3 mm diameter) appeared along old roots or root channels. At greater depths, the concretions formed continuous blocky structures or large single blocks (< 2 cm diameter).
- 7) The clay layer below was distinguished by its heavy texture and pallid colour, although the transition was diffuse. The clay may be mottled, but no concretions were found here.

Each layer was represented across the whole of the lake and only changed significantly at the lake margins where the sediments showed alternate layers of sand, clay and peat, although some sand was almost always present (Fig. 3).

Loss on ignition was an approximate guide to the organic matter content of the sediment. The values for the peat were high, around 45-60%, but fell to about 15% in the diatomaceous layer. Values peaked at 25% for the sandy peaty clay layer, then declined to 10% in the clay layers and finally dropped to 5-7% in the pallid clay (Fig. 3).

Radiocarbon dates are shown in Table 1 and on Fig. 3. The lowermost date is 8,780 ± 160 radiocarbon years, which corresponds to 9,791 calibrated years BP, the whole of the Holocene. Surface peat was

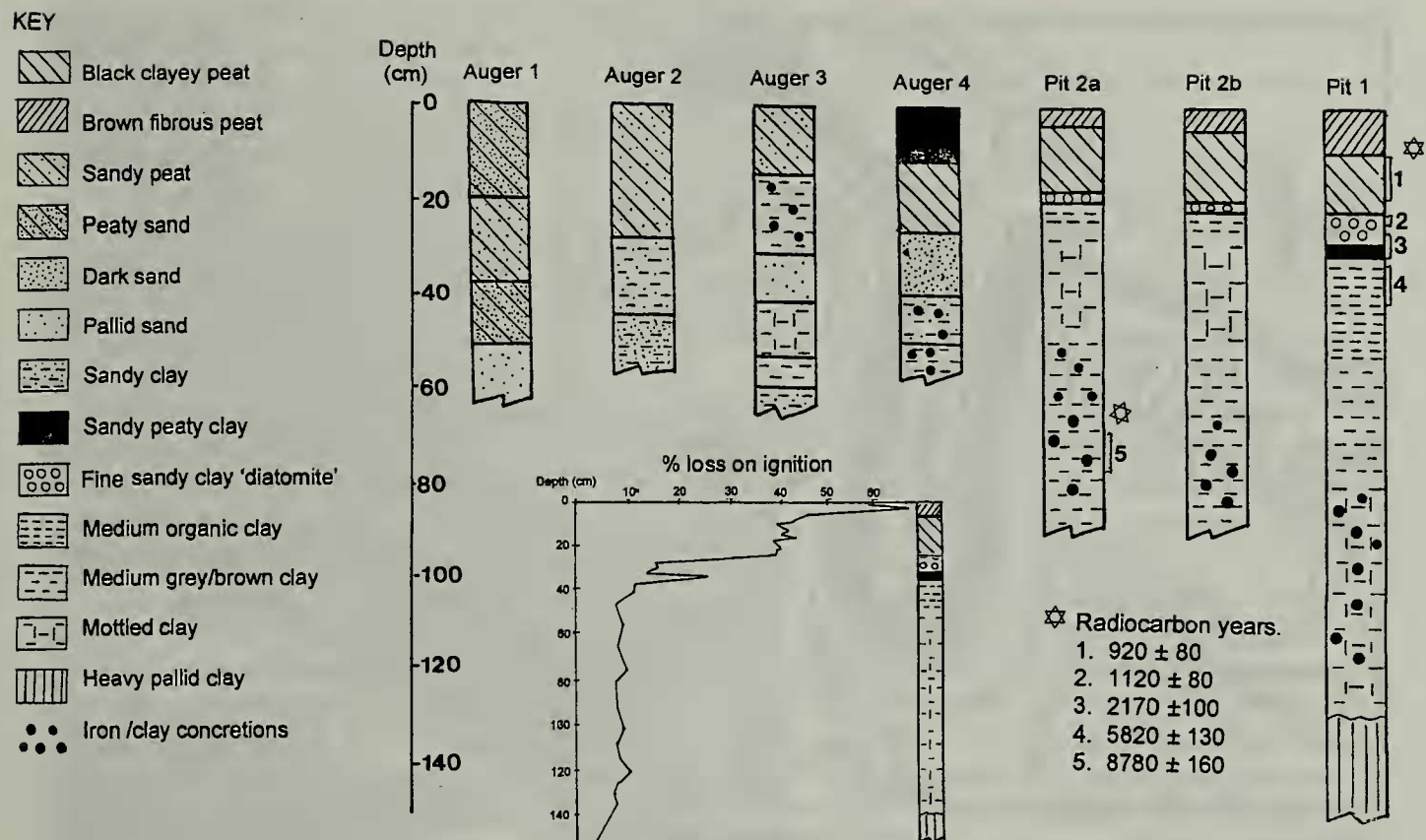


Figure 3. The stratigraphy of the sediments of Dry Lake.

Table 1. Radiocarbon dates. Calibrated years has been calculated according to the Radiocarbon Calibrated Program Calib Rev5.0.2 (Stuiver and Reimer, 1986-2005)

Sample	Depth (cm)	Material dated	Radiocarbon years BP	Calibrated years BP
Pit 1				
	10-20	Black clayey peat (humic acid fraction)	920±80 (NSW 375)	795
		Charcoal	1,120±80 (NSW 381)	986
	22-24	Humic acid in charcoal	1,560±120 (NSW 380)	1,417
		Peat (around charcoal)	1,660±90 (NSW 384)	1,499
	24-32	Diatomite (humic acid fraction)	2,170±100 (NSW 376)	2,101
	38-45	Organic clay (humic acid fraction)	5,820±130 (NSW 377)	6,570
Pit 2				
	73-83	10 cm length of wood	8,780±160 (NSW 387)	9,791
		Wood (humic acid fraction)	8,060±300 (NSW 388)	8,899

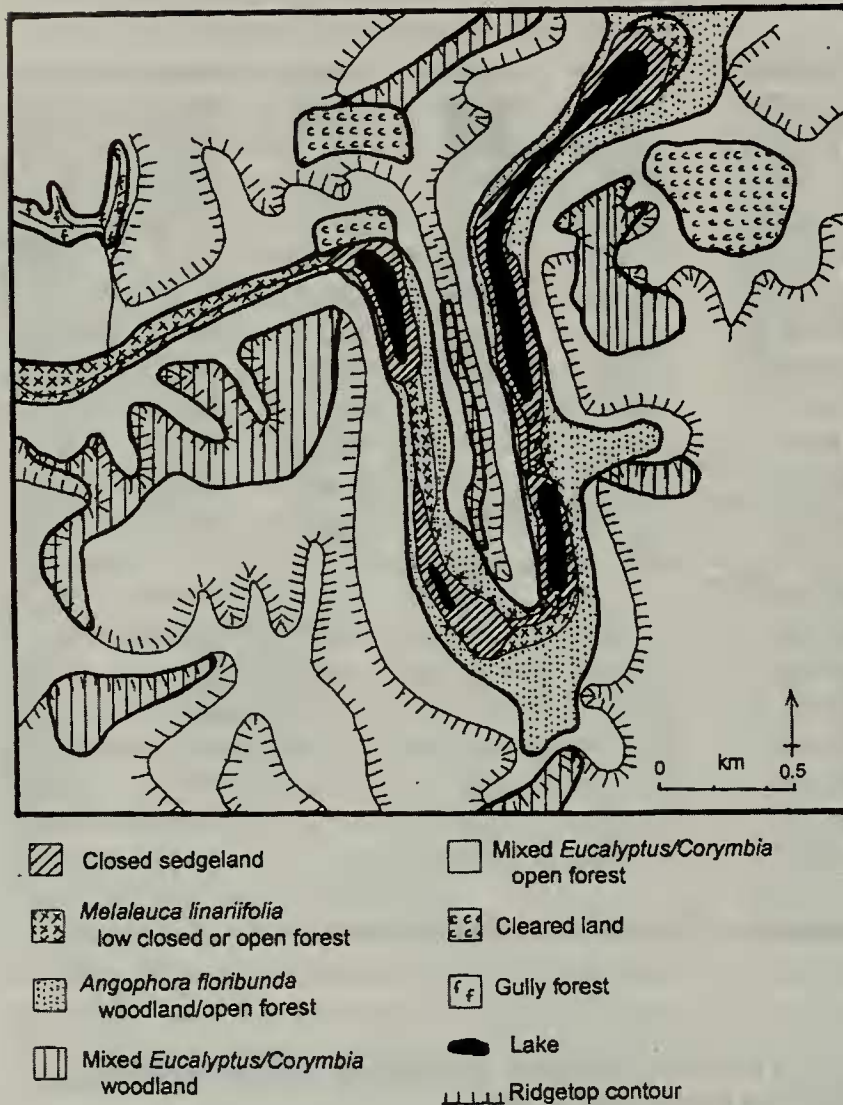


Figure 4. The vegetation of the Thirlmere Lakes region.

deposited most rapidly, i.e., 24-26 cm in 1,100 years and the diatomaceous earth (about 5 cm in depth) represents another 1,000 years. There appears to be an hiatus in the sediments, representing a period of zero or minimal deposition, or a period of erosion, between the diatomaceous earth ($2,170 \pm 100$ C¹⁴ years, see Table 1 for calibrated years) and the organic clay ($5,820 \pm 130$ C¹⁴ years) immediately below it. Wood and charcoal dates are regarded as the most reliable, whereas humic acids may move from their place of origin and contaminate material elsewhere. Table 1 reveals that where charcoal and humic acids have been dated from the same stratigraphic layer, there is relatively little difference.

Sedimentary history

The alternation of fine clay, peat and coarse sediments on the lake margin reflects the advance and retreat of the littoral zone in response to fluctuating water levels. Increasing clay content away from the

littoral zone reflects deeper water where the dominant process is the settling of fine particle sizes. The peat indicates organic material accumulated more rapidly than it decomposed, reflecting a consistently high water table.

From the beginning of the Holocene up to about 6-5,000 years ago, the site was a lake depositing clay. The pallid clay, the deepest layer, the mottling and the iron concretions in the layer above the pallid clay suggest a fluctuating water table and the lake may have dried out periodically. It is not clear what happened in the period 5-2,000 years BP, represented by the hiatus in the sediments.

An explanation for the 5 cm. thick diatomite layer must remain speculative. An explosion in the diatom population would require a considerable quantity of nutrients, and it is unlikely that the sandstone substrate of the catchment could supply these nutrients. Burning appears the most likely way of increasing the nutrient mobility. Unfortunately, an hiatus provides no evidence at all.

For the last 2-1,000 years, the lake has been shallow enough to allow the rooted swamp vegetation. The Holocene history is thus the evolution of a lake gradually filling up with sediments.

The Vegetation

Appendix 1 lists all the species in the study area and Fig. 4 shows the general distribution and extent of the vegetation units which are as follows:

1. Low closed forest with emergent trees dominated by *Eucalyptus deanei* (Fig. 5), up to 35 m tall. This unit is restricted to the floors and steep-sided gullies. Below this tall open forest canopy is a low closed forest with a great diversity of small rainforest trees, including *Pomaderris* spp., *Backhousia myrtifolia*, *Acmena smithii*, *Doryphora sassafras*, *Ceratopetalum gummiferum*. *C. apetalum* and *Stenocarpus salignus*. Below this is a closed scrub with many sclerophyllous species, including *Grevillea mucronata*, *Leptospermum trinervium*, *Persoonia levis* and *Lomatia silaifolia*. Abundant twiners are also present, including *Smilax australis*, *Cissus antarctica* and *Sarcopetalum harveyanum*. The ground cover is a closed fern/



Figure 5. Low closed forest with emergent *Eucalyptus* species is restricted to the floor of steep gullies.

herbland with *Gleichenia microphylla*, *Blechnum nudum*, *Sticherus flabellatus*, *Drosera auriculata* and many orchids.

The gully is protected from wind and fire, and is moist and well shaded. The soils are of variable thickness and are highly organic. Other more open gullies have some of these characteristics but are dominated by sclerophyllous shrubs and do not have such a complex structure.

2. Mixed *Eucalyptus*/*Corymbia* forest is the most extensive unit occupying the well drained slopes and ridges. The structure of the tree canopy is variable, with open forest on the more sheltered sites and south-facing ridges, with *Eucalyptus piperita*, *E. resinifera*, *E. punctata*, *Corymbia gummifera* and *C. eximia* (Fig. 6A). Low open forest and woodland occupies the steep slopes, especially those with a northern or westerly aspect and along stony areas of the central ridge. Woodlands occur on the most extreme sites with

greatest exposure to westerly winds and excessive drainage and here *C. eximia* and *E. racemosa* are the main species, with minor occurrences of the species mentioned above. Small trees of *Persoonia levis*, *P. linearis*, *Allocasuarina torulosa* and *Xylomelum pyreiformis* are occasionally found here.

The understorey is typically an open heath, dominated by the families Proteaceae and Fabaceae (especially *Acacia* spp.). Other common species include *Pimelea linifolia*, *Platysace linearifolia* and *Eriostemon* spp. The shrub layer is diverse and highly variable, due to a complex of environmental factors. At sites impacted upon by recent fire, the shrub layer has reduced diversity and density. The main species are *Acacia* spp., *Indigofera australis* and *Hibbertia aspera* (Fig. 6B). The groundcover is a dense sward of *Imperata cylindrica* and *Pteridium esculentum*.

The groundcover is generally open on ridgetops and steep rocky slopes and closed on the footslopes and nearer the lake margins. The herbs include *Opercularia* spp., *Viola betonicifolia*, *Pratia purpurascens*, *Gonocarpus tetragynus* and climbers *Glycine clandestina* and *Kennedia rubicunda* are more important on moister ground, including the alluvial areas adjacent to the lakes and southern facing slopes. In most other situations, grasses and *Lomandra* species predominate. *Lomandra obliqua* is common on well drained slopes and ridges and *L. longifolia* is abundant on the moister foot slopes.

3. *Angophora floribunda* dominated woodland and open forest is found on alluvial fans adjacent to and between lakes. *A. floribunda* is not common on other sites. Other tree species which are common at these sites include *Eucalyptus resinifera*, *E. piperita* and *Corymbia gummifera*. Smaller trees include *Allocasuarina littoralis*, *Banksia serrata* and *Persoonia levis*.

The shrub layer of this woodland is an open heath similar to that of the Mixed *Eucalyptus*/*Corymbia* Forest but *Banksia spinulosa* and *Pultenaea villosa* are often important components. *P. villosa* is generally restricted to these alluvial areas and may be locally dominant.

Groundcover is usually closed grass/herbland. On the most poorly drained sites, *Lepidosperma longitudinale*, *Schoenus* spp. and *Balioskion gracilis* are important. Alluvial fans are characterised by deep soils, gentle slopes and the

site drainage is moderate to poor.

4. *Melaleuca linariifolia* low closed or low open forest is mostly confined to a narrow area fringing the lake margins and along the swampy parts of Blue Gum Creek. It is most extensive on flat, low lying and periodically inundated sites adjacent to the lakes (Fig. 7).

The canopy is dominated by *M. linariifolia*, open or closed and 6 to 7 m high. *A. floribunda* is often present, usually as saplings on the drier landward margins of the unit. A few shrubs occur, e.g. *Viminaria juncea*, *Acacia longifolia* and *Pultenaea villosa*. At some sites, this unit and the *A. floribunda* woodland/open forest are difficult to distinguish and the *M. linariifolia* low open forest gives way to *Angophora* forest as the site becomes less subjected to periodic inundation.

The groundcover is closed or open sedgeland with *Schoenus* spp., *Lepidosperma longitudinale* and *Juncus* spp. The lakes contain occasional dead *M. linariifolia* stumps in 2 m of water, indicating a period of low water level which must have existed long enough for

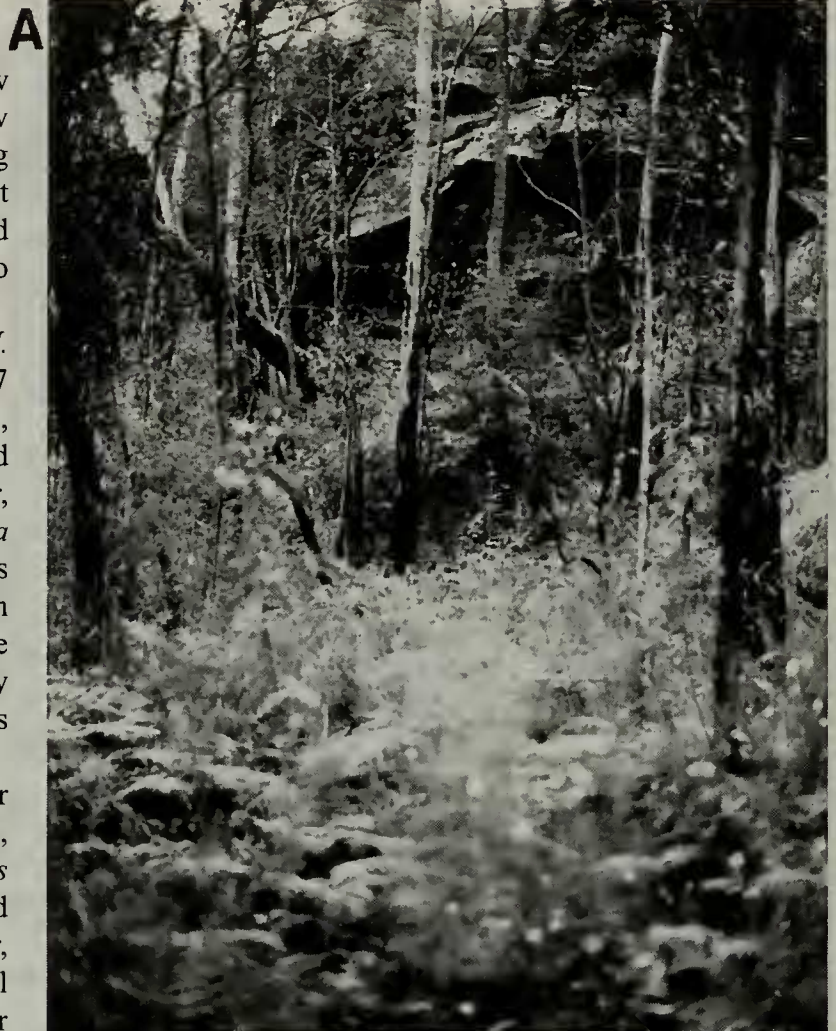


Figure 6. Mixed *Eucalyptus/Corymbia* forest. A, more sheltered site. B, a site with a reduced shrub layer and a ground cover of *Imperata cylindrica* and *Pteridium esculentum*, the result of fire in recent years.



Figure 7. *Melaleuca linariifolia* low closed or open forest at the lake edge.

M. linariifolia to become well established.

5. A closed sedgeland occurs as a continuous fringe around and between each lake. Aquatic vegetation is usually distinctly zoned according to water depth, however, there is considerable overlap between species distribution as shown on Fig. 8 and some species may change their distribution over time. For example, Vorst (1974) noted that *Elaecharis sphacelata* grew on the landward side of *Lepironia articulata*, but it now has a patchy distribution on both the landward and lakeward sides of *L. articulata*. This may have been caused by the lowering of water levels since 1974.

The distribution of aquatic plants, especially rhizomatous sedges is probably constantly changing with water level fluctuations and possibly competition. Lake 3 of Thirlmere Lakes (Lake Baraba) is almost dry and covered by an extensive sedgeland of *Lepidosperma longitudinale* onto which *Melaleuca linariifolia* is encroaching (Fig. 9).

6. Dry Lake. The land around Dry Lake is mostly cleared (see Fig. 2). The vegetation on the slopes adjacent to the lake is largely grassland/herbland with native species, e.g. *Imperata cylindrica*, *Themeda australis*, *Goodenia hederacea*, *Pratia purpurescens* and *Wahlenbergia* spp., and introduced species, including *Paspalum dilatatum*, *Echinopogon* spp., *Setaria geniculata*, *Hypochoeris radicata*, *Plantago lanceolata*, *Conyza* spp. and *Verbena bonariensis*. Regrowth of

trees and shrubs is occurring over most of the land and is most advanced nearest the swamp where the soils are moister.

Dry Lake itself is a swamp but it has surface water in wetter periods. It is surrounded by a discontinuous fringe of *Lepidosperma longitudinale* which appears to be advancing onto the swamp (Fig 10). A patchy cover of herbs on the lake includes *Gonocarpus micranthus*, *Dichondria repens* and some grasses. The wettest patches are almost bare apart from the occasional *Polygonum decipiens* and *Hypochoeris radicata*. In 1981, a dead reed, probably *Lepironia articulata*, covered most of the lake basin. Live rhizomes of the reed are abundant in the peat. A channel dug through the centre of the basin and containing about 60 cm of water has some *Elaecharis sphacelata*, *Potamogeton tricarinatus*, *Persicaria orientale* and several other sedges.

Towards the eastern margin of Dry Lake, inside the fringe of *L. longitudinale*, there are a number of old tree stumps, some of which are quite large (up to 40 cm in diameter). They are not *Melaleuca linariifolia* but are possibly *Eucalyptus/Corymbia* or *Angophora* spp. They probably represent a period of reduced moisture balance which was long enough and suitable for the growth of trees.

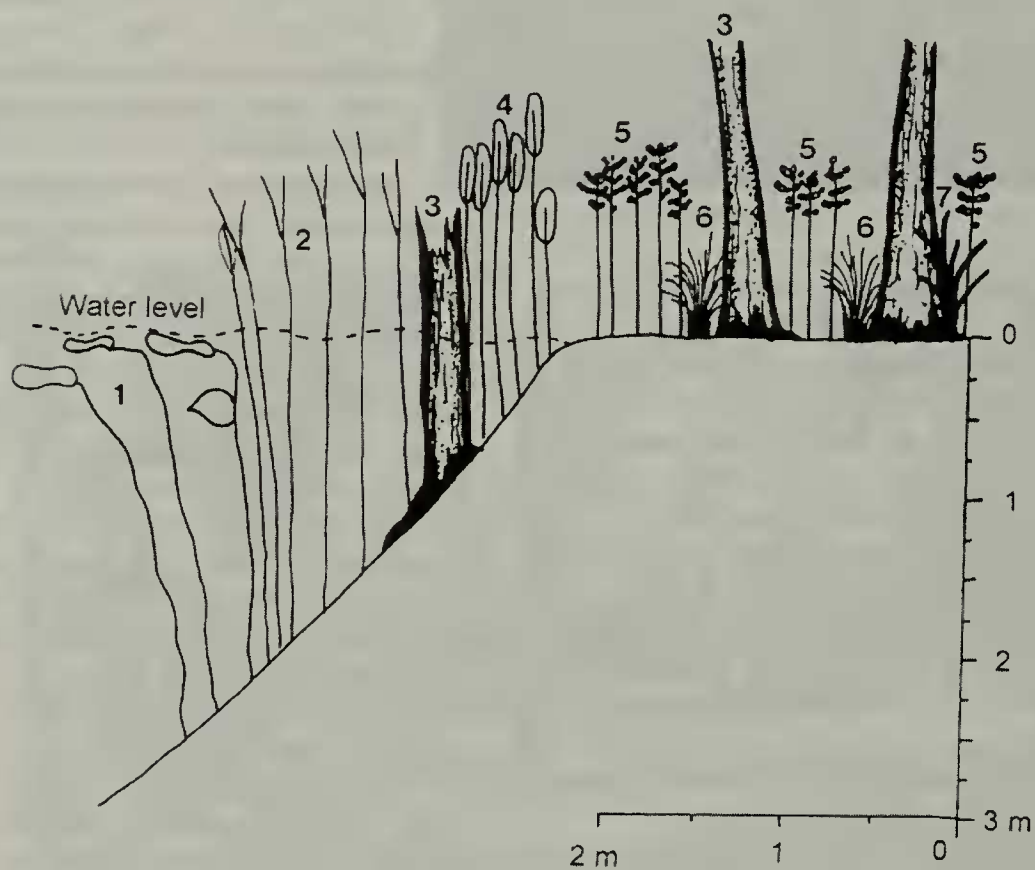


Figure 8 Aquatic vegetation. 1, *Brasenia schreberi*. 2, *Lepironia articulata*. 3, *Melaleuca linariifolia* stump. 4, *Eleocharis sphacelata*. 5, *Lepidosperma longitudinale*. 6, *Baloskion gracilis*. 7, *Schoenus brevifolius* and *S. melanostachys*.

Modern Pollen Deposition

Pollen is produced by the contemporaneous vegetation, but a multitude of factors affect the representation of pollen in the sediments (Birks and

Birks, 1980; Dodson, 1983; Moore et al., 1991), hence it is not possible to relate fossil pollen assemblages directly to the vegetation which produced it.



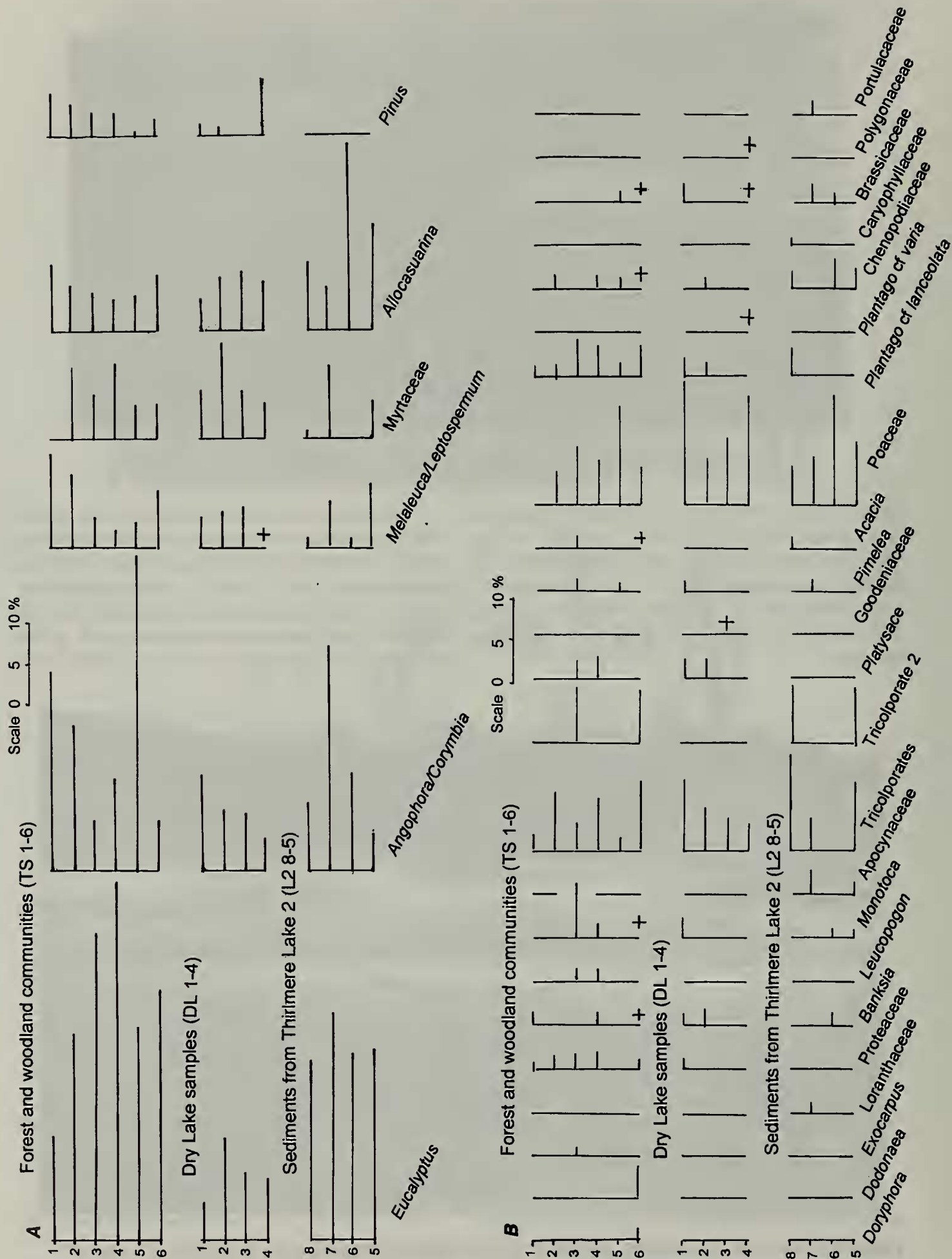
Figure 9. An extensive sedgeland on an almost dry Thirlemere lake.

Samples taken from beneath the present vegetation give some information about modern pollen deposition which may be used for interpretation of the fossil assemblages. Table 2 describes the surface sample sites and the associated vegetation growing there, and Fig. 11 shows the surface sample pollen spectra.

Comparison of the representation of the pollen with the taxon in the vegetation allows recognition of well-represented taxa, where pollen and vegetation representation are similar, over-representation, where pollen abundance exceeds abundance in the vegetation and under-representation, with pollen abundance less than abundance in the vegetation. This



Figure 10. Dry Lake, showing the central drainage channel and marginal *Leipidosperma longitudo-nale*. The surrounding slopes are cleared.



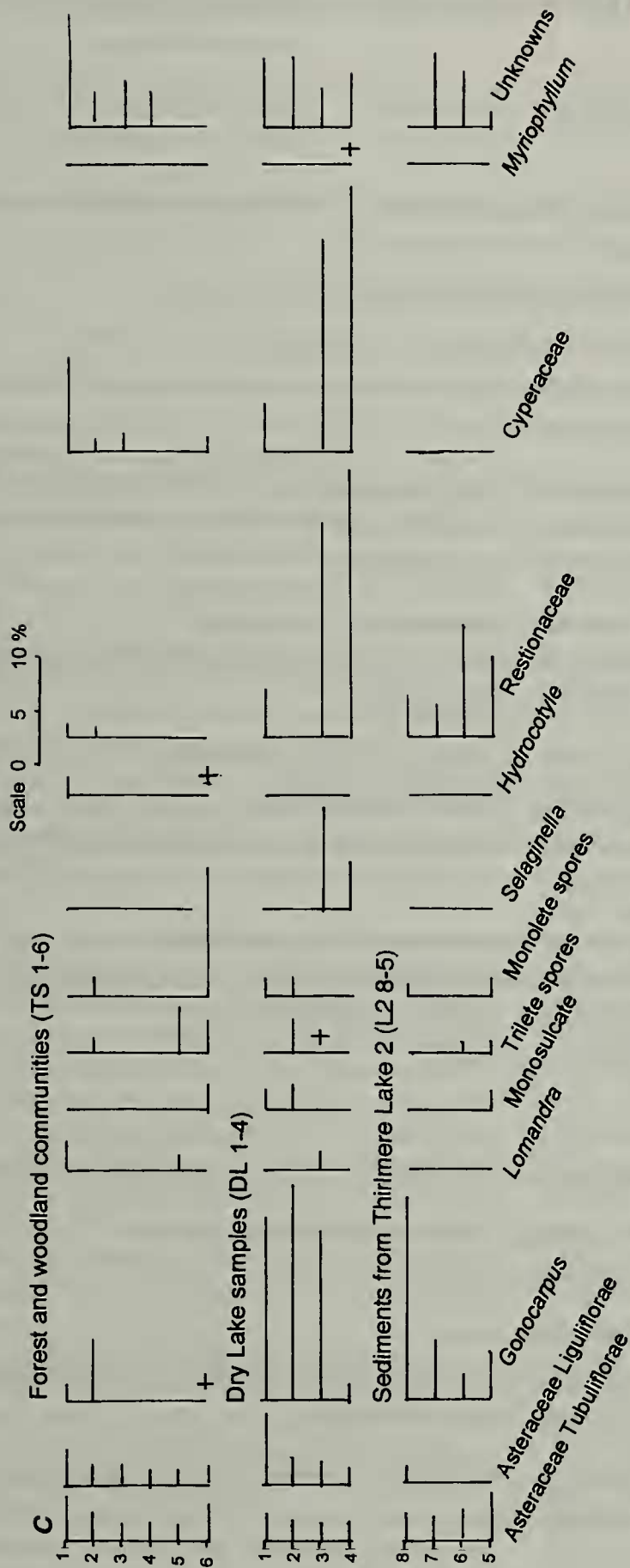


Figure 11 Modern pollen deposition. For the location of surface sampling sites, see Figure 1. For the probable source of the pollen in the vegetation, see Appendix 3. +, rare, present but not counted. Compare with the vegetation at the site in Table 2.

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Table 2 Surface sample collecting sites and their vegetation. Compare with pollen representation in Fig. 11.

Sample	Site details	Vegetation
Forest and woodland sites		
TS 1	Lake margin, on alluvium	Low, open forest of <i>Melaleuca linariifolia</i> and <i>Angophora floribunda</i> saplings, Closed sedge and cyperaceous reeds.
TS 2	Colluvial footslope	Open forest dominated by <i>Corymbia</i> spp. Open heath dominated by <i>Lambertia formosa</i> , <i>Acacia linifolia</i> and <i>Platysace linearifolia</i> .
TS 3	Seep rocky slope	Open forest dominated by <i>Eucalyptus</i> spp., some <i>Corymbia</i> spp. Open heath dominated by <i>Banksia spinulosa</i> , <i>Platysace linearifolia</i> . Open grassland with <i>Lomandra cylindrica</i> .
TS 4	Ridgetop plateau	Low open forest dominated by <i>Corymbia</i> spp. Open heath dominated by <i>Lambertia formosa</i> , <i>Grevillea mucronata</i> , <i>Eriostemon</i> spp. Open grassland.
TS 5	Colluvial footslope, recently burnt	Open forest dominated by <i>Angophora floribunda</i> . Low shrubland dominated by <i>Acacia</i> spp. Closed grassland dominated by <i>Imperata cylindrica</i> , <i>Pteridium esculentum</i> .
TS 6	Gully	Tall open forest dominated by <i>Eucalyptus deanei</i> , Low closed forest dominated by <i>Pomaderris</i> spp., <i>Ceratopetalum gummiferum</i> , <i>Tristaniopsis</i> sp. aff <i>laurina</i> . Fernland ground cover.
Dry Lake sites		
DL 1	Colluvial slope	Closed grassland dominated by <i>Conyza parva</i> , <i>Eragrostis brownii</i> .
DL 2	Colluvial slope	Low shrubland with <i>Leptospermum juniperinum</i> Closed grassland as above.
DL 3	Margin of lake	Low shrubland as above Grassland/sedgeland dominated by <i>Eragrostis brownii</i> , <i>Lepidosperma longitudinale</i> , <i>Selaginella uliginosa</i> .
DL 4	Centre of Dry Lake	Herbfield with <i>Gonocarpus micranthus</i> , <i>Persicaria decipiens</i> , and <i>Hypochoeris radicata</i> .

Thirlmere Lake sites

L2 5	50 m from lake margin, open water 3 m deep	Open water, no vegetation.
L2 6	20 m from lake margin, open water 3 m deep	Open water, no vegetation.
L2 7	5 m from lake margin, water 2 m deep	Closed sedgeland of <i>Lepironia articulata</i> , <i>Eleocharis spacelata</i> , <i>Brasenia schreberi</i> .
L2 8	0.5 m from lake margin, water 40 cm deep	Closed sedgeland as above.

study did not reveal any well represented taxa. Over-represented taxa include *Eucalyptus*, *Angophora/Corymbia*, *Allocasuarina*, Poaceae and *Gonocarpus*. Under-represented taxa were by far in the majority, since pollen of many species in the vegetation was never observed. Under-represented taxa include Proteaceae, *Acacia*, *Leucopogon*, Restionaceae, *Platysace*, *Pimelea*, *Melaleuca*, *Leptospermum* and pteridophytes. Some taxa are difficult to classify into any group, e.g. *Monotoca*, which was mainly under-represented, except in one sample, where it was over-represented. Given limited pollen dispersal (Birks and Birks, 1980; Dodson, 1983; Kodela, 1990), unusually high concentrations of under-represented taxa probably indicate that the plant was growing at the site.

Pollen spectra from the Dry Lake samples were very different from other spectra in this study (Fig. 11). The differences are related to the clearance of native vegetation on and around Dry Lake, and reflects the more distant source of *Eucalyptus*. Dry Lake samples were dominated by Poaceae and *Gonocarpus* pollen and had slightly higher proportions of “weedy” taxa, e.g. Asteraceae Liguliflorae (probably *Hypochoeris radicata*) and *Plantago lanceolata* type which all grow at the site of deposition. Thus the advent of European clearing at Dry Lake should be easily recognized in the fossil pollen profile using these criteria.

Most samples from forest or woodland sites produced similar pollen spectra but there were two noticeably distinct samples. Surface sample TS 5 was collected from a recently burnt site and is distinctive with a shrub layer of reduced diversity and density, dominated by *Acacia* spp. and a dense groundcover of *Imperata cylindrica* and *Pteridium esculentum*. Sites which had not been burnt so recently have a denser and more diverse shrub layer and a more diverse groundcover (see Table 2). The pollen spectra

reflect these differences: recently burnt sites have a lower percentage of tricolporate grains (which includes many shrub taxa), no proteaceous pollen and much higher percentages of Poaceae pollen (perhaps *Imperata*) and trilete spores (probably *Pteridium*) than unburnt sites. *Acacia* pollen was not recorded from the surface samples although *Acacia* spp. were dominant in the understorey: it is highly under-represented.

At sites where *Angophora/Corymbia* were the canopy dominants (samples TS 1, TS 2, and TS 5), their percentages in the spectra was 15% or greater and usually higher than *Eucalyptus*. Thus values of 15% or more may infer a dominance of *Angophora/Corymbia* at the site. *Melaleuca/Leptospermum* was a poorly represented group. In a sample from *Melaleuca* low open forest (TS 1), this group reached 15%, the highest at any site, hence this value may be used to identify dominance in the vegetation.

Surface sample TS 6 was collected in a gully with tall open forest dominated by *E. deanei*, a dense understorey of several rainforest species and a dense ground-cover of ferns. *Eucalyptus* pollen still dominated the spectrum at 30%, but a greater diversity of palynomorphs are present. Pteridophyte spores, especially the monoletes, characterise the gully sample with a value of 15%, compared with 0-4% in other samples. Apart from these differences, the tall open forest pollen spectrum is hardly any different to those of open forest. The small rainforest trees were very poorly represented in the surface pollen spectrum. These results are in accord with those of Ladd (1979) and Kodela (1990) who found that small pockets of rainforest amongst widespread eucalypt vegetation were hardly detected by the palynological method.

The samples from Thirlmere Lake 2 show that pollen from taxa growing on the lake margin, e.g. *Gonocarpus* and poorly dispersed types, e.g. the

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tricolporate group are more important in the spectra near the lake margins (L2 7 and L2 8) where on site production is important. Well dispersed types, e.g. *Eucalyptus*, *Allocasuarina*, Poaceae and Cyperaceae are more important in pollen spectra from the lake centre (L2 5 and L2 6) which tends to accumulate wind dispersed pollen.

These surface pollen spectra provide some basis for interpretation of the fossil pollen spectra. However, the sensitivity of the palynological approach usually only allows identification of vegetation units to the formation level. It is unlikely that different *Eucalyptus* associations can be distinguished by the palynological method.

History of the Vegetation

Fig. 12 a-c presents the fossil pollen diagram from the profile through the lake sediments. Pollen content is expressed as percentages of total count for all taxa identified and as pollen concentration for the most abundant taxa. Because percentages must add up to 100, a change in abundance of just one taxon will influence the percentages of all other taxa. On the other hand, the pollen concentration of each taxon is independent of all other taxa, hence a change in just one taxon will be apparent. On the whole, the curves for pollen concentrations reveal similar information to those of percentages, with some exceptions.

The total pollen concentration (Fig. 12 c) is low in the lower part of the profile, below 40 cm, and generally higher in the upper part of the profile. The low pollen concentration section is found in the mottled clay which was subjected to a fluctuating water table that could have had a destructive effect on pollen. Thus the lower concentrations could be the result of destruction of some pollen or a lower pollen producing plant community. Cyperaceae is a thin-walled grained which may be easily destroyed in adverse environments, but it is found throughout this lower section of the profile. Indeed, the pollen spectra of the low pollen content section of the profile are generally comparable with the spectra in the high pollen content part of the profile, inferring that any pollen destruction has not appreciably distorted the spectra. An examination of the surface sample spectra together with the fossil spectra reveals the following:

Eucalyptus and *Allocasuarina/Casuarina* are the main trees in the lower part of the profile. *Allocasuarina/Casuarina* would have been more abundant in the vegetation than it is today. *Angophora/Corymbia* would have been a relatively minor part of the vegetation. Thus the vegetation would have been much the same from the beginning of the Holocene (10 ka ago) until the mid Holocene

(5 ka). Unfortunately, there was an hiatus and hence no record from about 5 ka until 2 ka. By then, *Angophora/Corymbia* had increased and it suggests that *Angophora* (more common on alluvial soils) may have been a canopy dominant (values > 15%) for much of the time. *Eucalyptus* percentages were a little less and *Allocasuarina* was still abundant, although it fluctuated somewhat. *Melaleuca/Leptospermum* would have been minimal in the early Holocene and more abundant in the late Holocene, but it was insufficient (< 15%) to indicate a fringing *Melaleuca* forest, similar to the Thirlmere Lakes today. As discussed previously, stumps on Dry Lake were unlikely to be *Melaleuca*, thus supporting this interpretation of the pollen content.

In the European zone (above 10 cm depth), all of these trees decrease, doubtless the result of timber cutting and agriculture.

Poaceae was moderate in the early Holocene, decreasing in the late Holocene when the tree cover increased, but increasing markedly in the European zone, no doubt due to forest clearing and agriculture. Asteraceae, which may have represented herb(s) or shrub(s) was noticeably more abundant in the early Holocene, decreasing after 5 ka and remaining low for the rest of the time. *Gonocarpus* is more abundant in the early Holocene, decreasing after 5 ka and remaining lower until the European zone where it was much reduced. Some Dry Lake samples show more abundant *Gonocarpus* which grows on the surface today. The abundance of Cyperaceae was moderate in the early Holocene, increasing after 2 ka and remaining high, although values fluctuated. Cyperaceae would have grown on the peat surface during the late Holocene, just as it does today.

The only shrubby and herbaceous taxa recorded in the early Holocene were Proteaceae, tricolporates, Chenopodiaceae and Brassicaceae. Since it was not possible to count sufficient grains required for adequate sampling from this low pollen concentration zone, and these other shrubs and herbs were under-represented taxa, their absence may be the result of inadequate sampling. Spores of ferns (monolet and trilete) and *Selaginella* were not recorded. From 2 ka to the present, shrubs and herbs were better represented. Spores of ferns and *Selaginella* were also present in this zone and they indicate conditions were somewhat wetter after 2 ka.

Some exotics are present in the European zone, viz. *Pinus*, *Plantago* cf. *lanceolatus* and Asteraceae Liguliflorae, assuming this pollen type represents *Hypochoeris radicata* and not a native species. As discussed previously, all the tree taxa are reduced and Poaceae increases markedly.

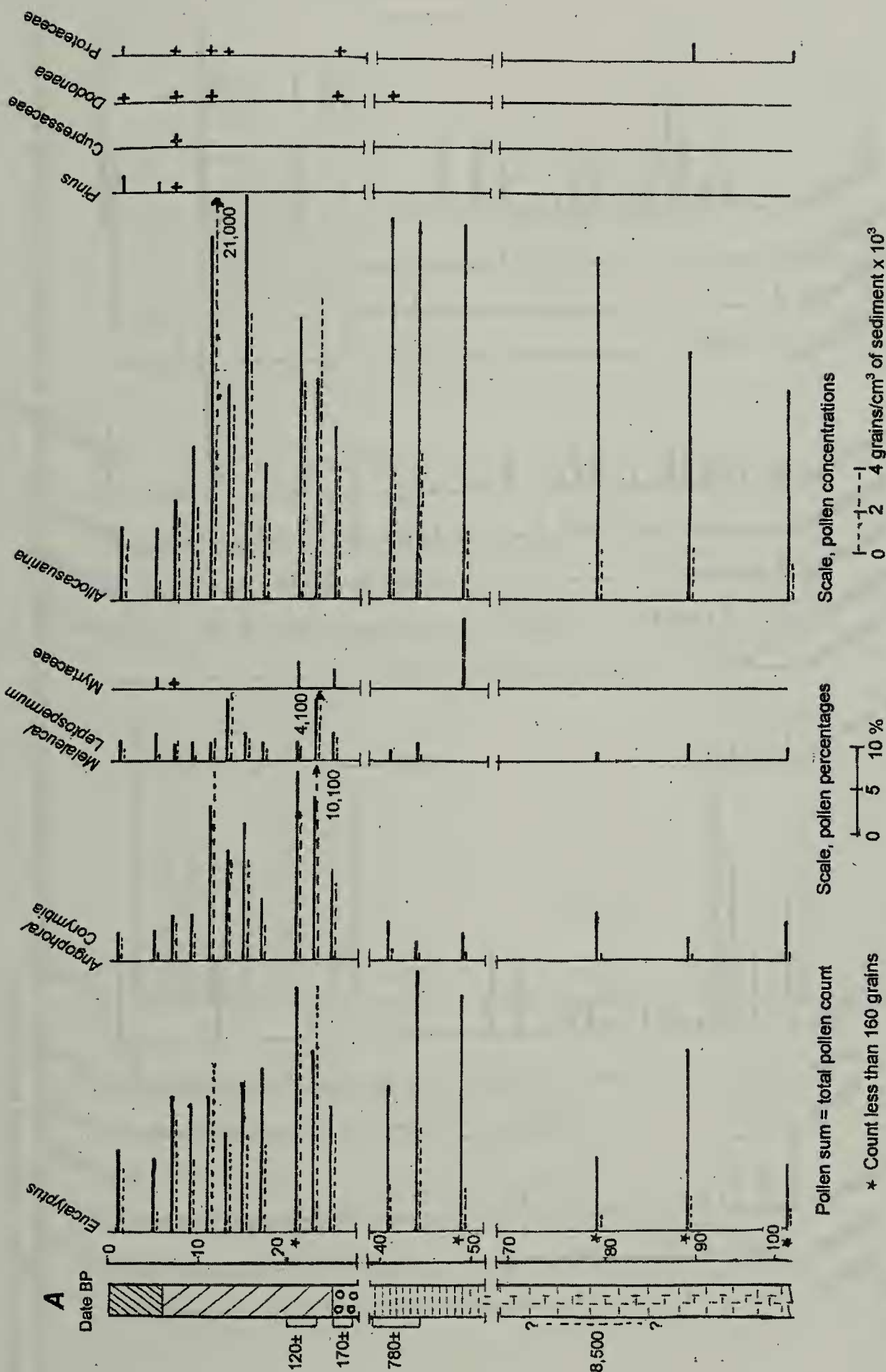


Figure 12. The pollen spectra of the Dry Lake sediments. For the probable source of the pollen for each name on the pollen diagram, see Appendix 3. +, rare, present but not counted.

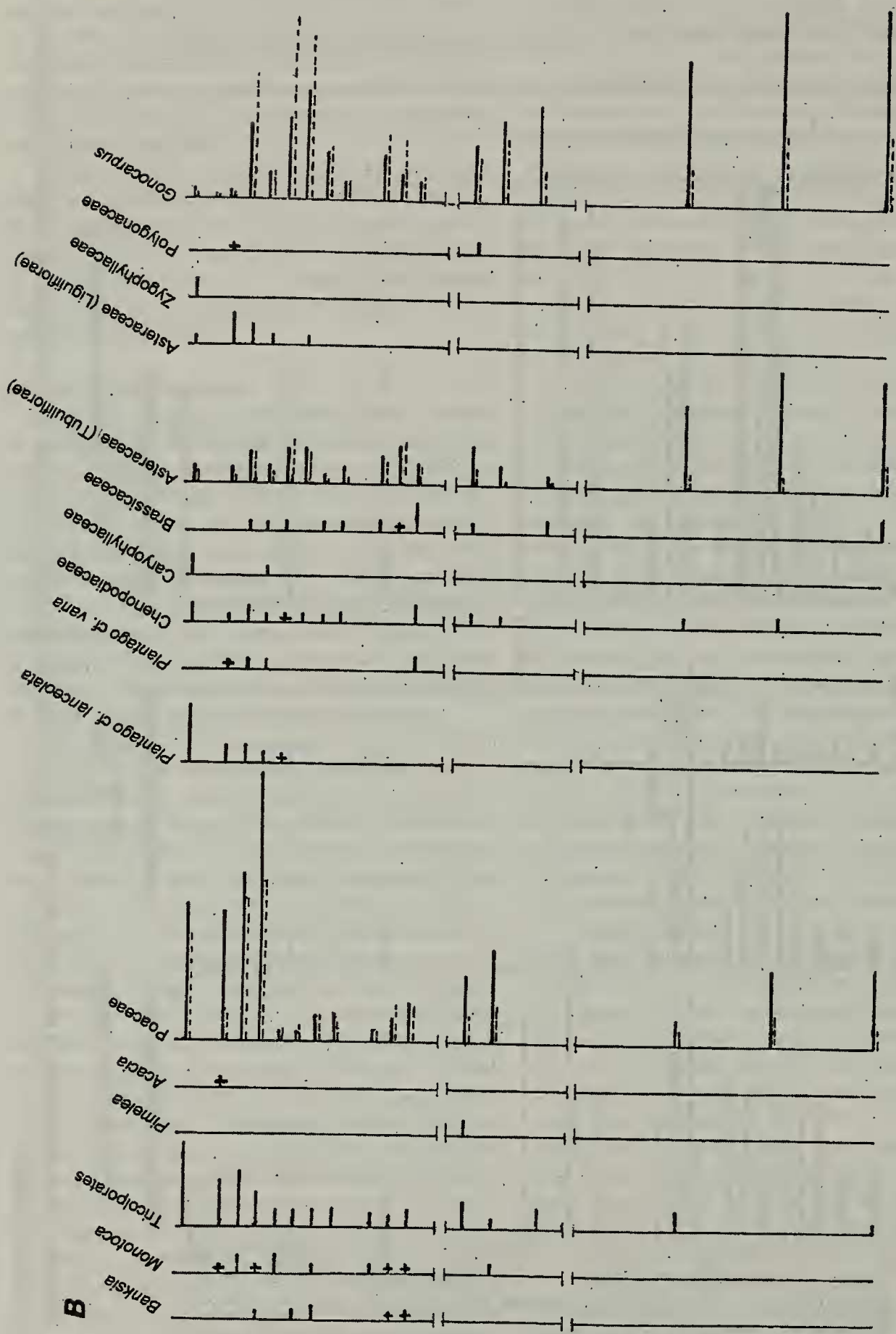


Figure 12 (continued). The pollen spectra of the Dry Lake sediments. For the probable source of the pollen for each name on the pollen diagram, see Appendix 3. +, rare, present but not counted.

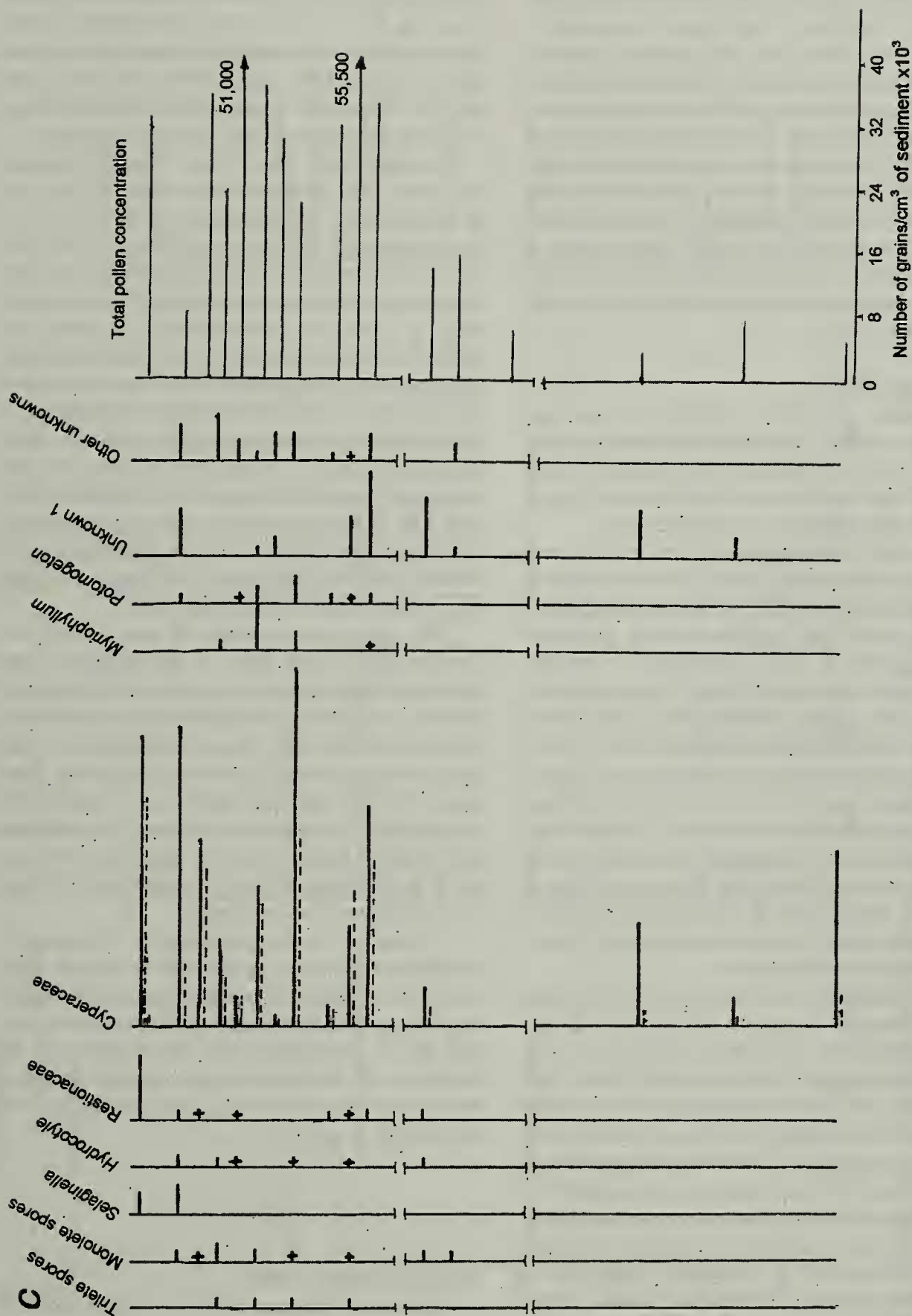


Figure 12 (continued). The pollen spectra of the Dry Lake sediments. For the probable source of the pollen for each name on the pollen diagram, see Appendix 3. +, rare, present but not counted.

In summary, the early Holocene vegetation was a *Eucalyptus/Allocasuarina/Casuarina* woodland/forest, with Asteraceae (Tubuliflorae) prominent in the understorey. *Gonocarpus* was probably common around the lake. In the late Holocene, *Angophora* woodland was present also and there was a diversity of shrubs in the understorey. The lake had become a peat swamp and Cyperaceae grew on and/or around the swamp. After Europeans arrived, the trees decreased and, grasses increased markedly. Today, *Angophora* woodland is found on the deeper, moister soils of the alluvial fans, hence its development around Dry Lake in the late Holocene probably indicates a wetter climate at that time.

Siliceous microfossils

Treatment for the recovery of siliceous microfossils yielded sponge scleres, diatoms, plant phytoliths and sand grains. Only sponge scleres were studied in detail, however some observations of diatoms or plant phytoliths are reported here.

Freshwater sponges occur in most semi-permanent and permanent inland waters of Australia. Distribution of the species are not uniform and is largely governed by physiochemical properties of the environment. Only one species of sponge, *Radiospongilla szeptroides* Haswell is present in the Thirlmere Lakes system (NPWS, 1997). This species has a wide but scattered distribution east of the Dividing Range and has a preference for non-alkaline environments (Racek, 1969). *R. szeptroides* produces a vivid green pigment and lives mainly on fallen logs, branches and leaves in the littoral zone where water fluctuations are most frequently experienced (Racek, 1969). It is thought that the relative abundance of sponge scleres could be used as an indicator of water depth and lake level fluctuations.

Two surface samples were studied: SS 1 from the lake margin and SS 2 from the lake centre (Fig. 13). The lake margin had 20 times the megasclere (body scleres) numbers than found at the lake centre. The lake margin is the habitat of the sponge and few scleres are apparently transported to the lake centre in this low energy environment. There were also appreciable numbers of gemmoscleres (carried on the gemmules), showing that the sponges were gemmulating in the not too distant past. Today, *R. szeptroides* does not form gemmules which are produced in response to adverse environmental conditions (Racek, 1969; NPWS, 1997).

Few scleres were found in the clays at the base of the sediments. The lake was probably much larger and deeper then and the sponge habitat would have been too far away for many of their scleres to be

deposited at this site. There are two peaks in the values for megascleres: at 31 cm and a much larger one at 51cm, the latter at the base of the diatomite. These peaks suggest that the lake had become shallower and smaller, such that the sponge habitat was close to this site. The megasclere content was moderate through most of the profile, declining towards the surface.

Gemmoscleres were also found throughout the profile, and in appreciable numbers. The ratio of gemmoscleres to megascleres is an indicator of the harshness of the conditions (Racek, 1969). The two surface samples from Thirlmere Lakes have extremely small ratios, which indicate that conditions today are not often harsh enough to induce the sponges to form gemmules. The highest ratio of gemmoscleres to megascleres were found at the base of the diatomite. The ratio of megasclere fragments to entire megascleres was quite high, especially in the lake margin sample. This ratio may indicate how well the sponge remains were preserved in the sediments, especially at depth. However, the large number of fragmented sponge remains in the shallowest depths probably indicate mechanical breakage and being silica, the scleres do not decompose.

The high concentration of megascleres and gemmoscleres at the base of the diatomite were associated with a high concentrations and diversity of diatoms. Phytoliths were abundant also, and all these siliceous microfossils, being comparable to sand grains which are more common in the littoral zone, suggest that the lake was shallow and swamp plants were growing on or close to the site. The diatomite also contains a higher content of sand grains than any, which is indicative of shallow water of the littoral zone, the habitat of *R. szeptroides*.

In general, high concentrations of phytoliths were found from 50 cm upwards, or in that part of the profile that is organic. This high concentration implies that swamp vegetation had colonized the lake surface from the 50 cm level upwards. Below this level, the abundance of phytoliths was low, suggesting that little swamp vegetation was nearby and the lake was too deep for its growth.

DISCUSSION

The history of Dry Lake

In the early Holocene (from 10 ka), Dry Lake was relatively deep, with a calm, low energy environment depositing clay. The margins probably supported some cyperaceous reeds and *Gonocarpus*, but a fringe of paperbarks (*Melaleuca linariifolia*), similar to the

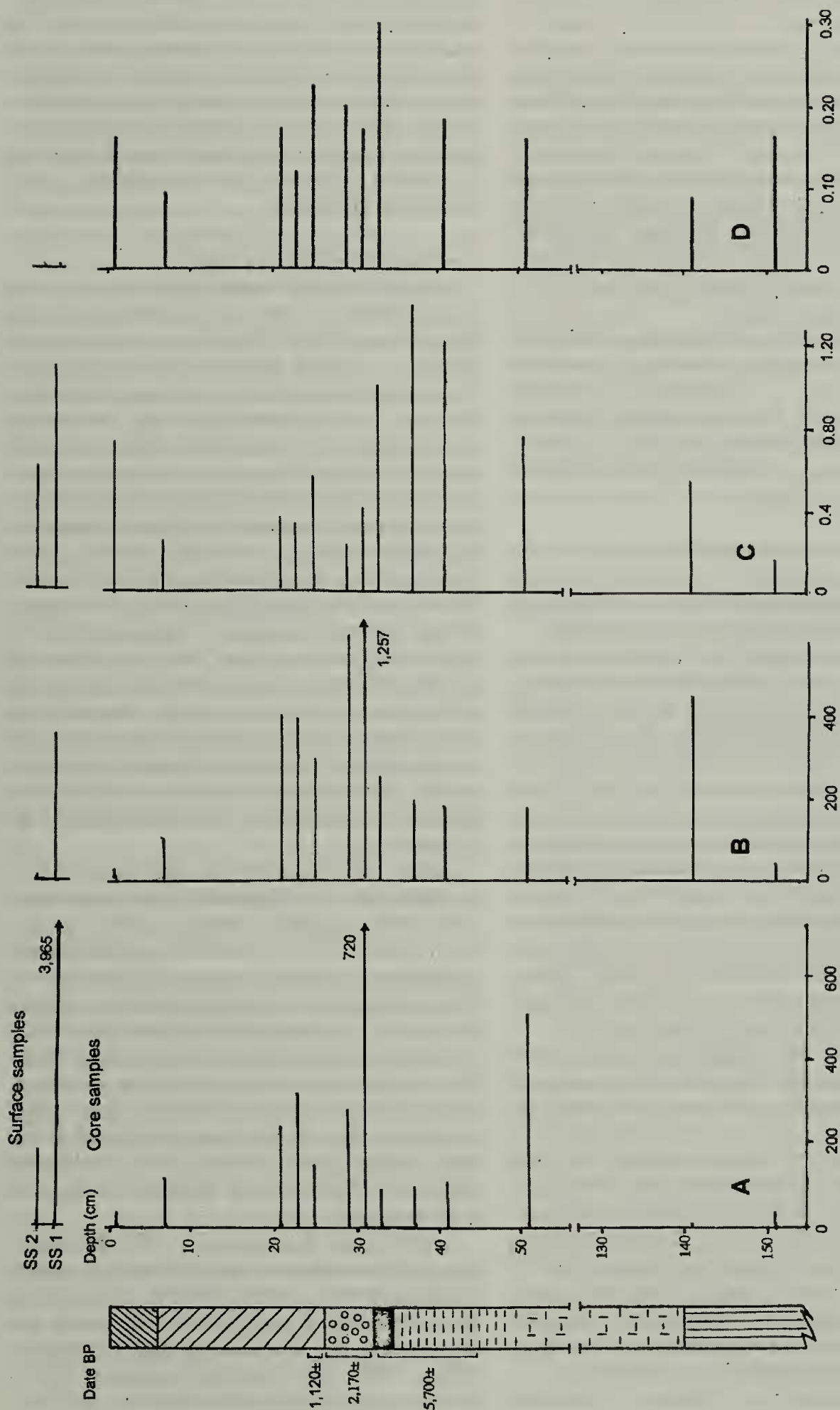


Figure 13. Sponge microfossils. A, Number of megascleres/cm³ sediment x 10³. B, Number of gemmoscleres /cm³ sediment x 10³. C, ratio of megasclere fragments to whole megascleres. D, Ratio of gemmoscleres to megascleres.

Thirlmere Lakes today, was lacking. The freshwater sponge, *Radiospongilla szeptoides*, lived round the margin of the lake, amongst fallen debris. *Eucalyptus* spp. and *Allocasuarina* were the dominant trees in the surrounding vegetation and Asteraceae (Tubuliflorae) was prominent in the understorey, probably as a shrub. Some grasses (Poaceae), Proteaceae, tricolporates (most likely shrubs) and Chenopodiaceae were also present in the early Holocene. Although generally high, lake levels must have been very variable and the lake probably dried up for extended period(s), causing the formation of the pallid and mottled clays at the deepest parts of the lake.

Between 8 ka and 5 ka, the lake became shallower and the fringing swamp vegetation grew over much of the lake surface. In the catchment, density of the *Eucalyptus* and *Allocasuarina* trees increased somewhat, Asteraceae was much reduced and shrubs and herbs increased in diversity, with *Dodonaea*, *Monotoca*, *Pimelea*, Brassicaceae and Portulacaceae being recorded.

From 5 ka to 2 ka, there was an hiatus in the deposition of the sediment, or the sediments that were deposited were subsequently eroded. Unfortunately, this means there is no information for this period.

About 2 ka, a shallow lake returned, probably covered with swamp vegetation and sufficiently nutrient rich to support large populations of diatoms and sponges. It is not clear how this nutrient rich status was achieved, given the nutrient-poor sandstone of the catchment. Decaying swamp vegetation would increase the nutrient status, but it would require a high nutrient status to produce a good plant cover in the first place. Burning may also mobilize nutrients. Unfortunately, there is no evidence about which is the more likely hypothesis in this case. This enriched nutrient status did not last long, and the diatom and sponge populations decreased to 'normal' levels. The lake remained shallow and probably supported swamp vegetation over most of its surface.

After 2 ka, the *Angophora/Corymbia* group increased dramatically. Today, *Angophora* dominates the alluvial fans and soils adjacent to the lakes, and *Corymbia* is more common on well-drained slopes and ridges, hence this increase around Dry Lake was more likely to have been *Angophora*. This change suggests a somewhat moister environment. *Eucalyptus* and *Allocasuarina* probably decreased slightly, *Melaleuca/Leptospermum* increased, but not sufficiently to indicate a fringe of *Melaleuca* around the lake. The diversity of shrubs and herbs increased further, and there was a considerable increase in cyperaceous swamp cover.

The introduced *Pinus*, *Plantago cf lanceolata*

and Asteraceae (Liguliflorae: probably *Hypochoeris radicata*) denote the zone of European influence. All the trees, viz. *Eucalyptus* spp, *Angophora/Corymbia* and *Allocasuarina* decreased markedly, no doubt the result of timber cutting. Grasses and the tricolporates, which could include any number of crop plants and weeds, would have been the result of agriculture. The cyperaceous reeds around the swamp remained, much the same as previously.

Comparisons with Other Studies

The history of the vegetation from a core in Lake Baraba (Thirlmere Lake 3 of this study, see Fig. 1), has been reported by Black et al. (in press). Lake Baraba is some 4 km south of Dry Lake. Peat began forming in the early Holocene, ~8.5 ka, earlier than at Dry Lake. Thus in contrast to Dry Lake, Lake Baraba had become shallow enough for the growth of swamp vegetation. At Lake Baraba, the dominant trees were Casuarinaceae which declined in the early Holocene, with a concurrent increase in Myrtaceae, thought to be the development of the fringing *Melaleuca* forest (Black et al., in press) which is present around the lake today. In contrast, at Dry Lake, *Allocasuarina* did not decrease, a fringing *Melaleuca* forest did not develop, and *Angophora* became prominent by the mid Holocene. At Dry Lake, the lake became shallow enough to support swamp vegetation and peat formation about the mid Holocene, later than at Lake Baraba. *Allocasuarina* remained prominent at Dry Lake until the European zone, unlike Lake Baraba where it remained low through most of the Holocene.

These differences between the two sites may be attributed to the differences in local topography. Lake Baraba is confined within a relatively narrow valley which is likely to afford some protection and provide more favourable moisture relationships than the Dry Lake locality, which is more open, in a broad alluvial flat. This topographic difference may explain why Dry Lake did not develop a fringing *Melaleuca* forest. Although these two sites are only 4 km apart, the limited nature of pollen dispersal, where most pollen falls close to the source (Birks and Birks, 1980; Dodson, 1983; Kodala, 1990) ensures that these local differences in the vegetation are recorded in the sediments.

A decline of Casuarinaceae, when *Eucalyptus* replaced Casuarinaceae, may be found in a number of Holocene sites in southern Australia and is usually dated between 7.5 and 4.5 ka. Importantly, not all Holocene sites show this decline (Clark, 1983; Dodson, 1994; 2001; Lloyd and Kershaw, 1997). It has been suggested that anthropogenic fire may have

been the cause of this change in dominant species, but the charcoal records generally do not support this hypothesis (Dodson, 2001; Kershaw et al., 2002; Black et al., in press). Another likely cause, a rising water table or salinity, may be supported by an increase in Chenopodiaceae pollen (Crowley, 1994; Cupper et al., 2000), but studies in the vegetation show that some species of Casuarinaceae are more salt tolerant than certain species of *Eucalyptus* (Ladd, 1988). The anatomy of the branchlets of Casuarinaceae, with their restricted photosynthetic tissue, make it a poor competitor with broad leaved species. Anatomically, Casuarinaceae species are very xeromorphic and in comparative studies, Casuarinaceae is more drought tolerant than *Eucalyptus* (Ladd, 1988).

As the climate ameliorated after the last glacial period, the grasslands/shrublands were invaded by Casuarinaceae which were in turn replaced by *Eucalyptus* in the Holocene (Clarke, 1983). The climate in the last glacial period was much drier, hence the change in vegetation parallels the climatic change, viz. the increase in moisture. Casuarinaceae remained on poor or harsh sites as it appears to tolerate these conditions better than *Eucalyptus* (Ladd, 1988).

At Dry Lake, *Eucalyptus* and *Angophora/Corymbia* increase, but Casuarinaceae does not decrease until it was logged by Europeans. Casuarinaceae was prized by the early settlers as firewood and it was the fuel of choice for bakeries. Its timber was in demand for shingles, tool handles, beer barrels and many other used (Entwistle, 2005). Indeed, the Oaks, some 15 km to the north of Thirlmere (Fig. 1) was so named for the abundant sheoaks (*Allocasuarina torulosa*). When the botanist George Caley passed through the district in 1804, he saw 'a large tract of grazing land abounding with sheoaks' (Woods, 1982).

The Casuarinaceae pollen has not been identified further; but it is assumed to be *Allocasuarina* in this study because there are only two species in the area today: *A. littoralis* and *A. torulosa*. *A. littoralis* is an understorey tree in woodland or occasionally tall heath, on sandy or otherwise poor soils. *A. torulosa*, also an understorey tree, is found in open forests to tall open forests, generally on higher nutrient soils and moisture situations than *A. littoralis* (Plantnet, 2005). The alluvial flat around Dry Lake would have been suitable for *A. torulosa*, but at Lake Baraba, in a sandstone valley, *A. littoralis* seems more likely. Thus the different history of Casuarinaceae at the two sites may have been the consequence of different species, as well as the different topography and soils.

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APPENDIX 1A

Species list of plants in the Thirlmere National Park, compiled from field work and augmented from a list prepared by the National Herbarium of New South Wales (*). +, introduced species.

Life forms: T, tree with single stem, > 8 m tall. S, shrub, woody plant < 8 m tall. H, herbs, non-woody plants. epiH, epiphitic herbs. aqH, aquatic herbs, growing in wet or periodically wet areas. C, creeper, prostrate herb or shrub. TW, twiner, climbing plant.

Pollination mechanisms (Poll'n Mech), from Faegri and van de Pijl (1971), Dodson (1979), Armstrong (1979), Ford et al. (1979) and Pyke (1981): A, anemophilous, wind pollinated. E, entomophilous, insect pollinated. O, pollination by other animals, e.g. birds, mammals. S, self pollinated. H, hydrophilous, water pollinated.

Nomenclature follows Harden (1992; 1993; 200; 2002) and Plantnet (2005).

Species	Life form	Poll'n Mech.	Occurrence/distribution
MYRTACEAE			
<i>Angophora floribunda</i> (Sm.) Sweet	T	A, E, O	Very abundant, lower slopes only
<i>Corymbia eximia</i> (Schauer) K.D. Hill & L. A. S. Johnson	T	A, E, O	Very abundant, esp. ridgetop plateaux
<i>C. gummifera</i> (Gaertn.) K.D. Hill & L.A. S. Johnson	T	A, E, O	Abundant
<i>Eucalyptus agglomerata</i> Maiden	T	A, E, O	Occasional
<i>E. botryoides</i> Sm.	T	A, E, O	*
<i>E. oblonga</i> Blakely.	T	A, E, O	Occasional, mostly steeper slopes
<i>E. piperita</i> Sm	T	A, E, O	Very abundant
<i>E. punctata</i> DC	T	A, E, O	Occasional
<i>E. racemosa</i> Cav.	T	A, E, O	Occasional
<i>E. resinifera</i> Sm.	T	A, E, O	Rare
<i>E. sieberi</i> L. Johnson	T	A, E, O	Occasional, esp. near ridgetop plateaux
<i>Leptospermum trinervium</i> J. Thompson	S	A, E.	Common, mostly on slopes
<i>L. polygalifolium</i> Salsb.	S	A, E	Rare, mostly on slopes
<i>L. juniperium</i> Sm.	S	A, E	Occasional, mostly lake margins
<i>Kunzea ambigua</i> (Sm.) Druce	S	A, E, O	*
<i>Melaleuca linariifolia</i> Sm	T	A, E, O	Abundant, mainly lake margins
<i>M. thymifolia</i> Sm.	S	A, E, O	Occasional, along lake margins
PROTEACEAE			
<i>Banksia integrifolia</i> L. f.	T or S	E, O	*
<i>B. serrata</i> L.f.	T or S	E, O	Abundant, mainly lake margins
<i>B. spinulosa</i> Sm.	S	E, O	Very abundant
<i>Grevillea arenaria</i> R. Br.	S	E, O.	*
<i>G. mucronulata</i> R. Br.	S	E, O	Very abundant
<i>Hakea dactyloides</i> Cav.	S	E, O	Occasional, moist sites
<i>H. salicifolia</i> (Vent.) B.L. Burt.	S	E,O	*

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<i>H. sericea</i> Schrad. & J.C. Wendl.	S	E, O	Rare
<i>Isopogon anemonifolius</i> Knight	S	E	Occasional
<i>Lambertia formosa</i> Sm.	S	E, O	abundant
<i>Persoonia lanceolata</i> Andrews	S	E	*
<i>P. laurina</i> Pers.	S	E	Occasional, esp. ridgetop plateaux
<i>P. levis</i> (Cav.) Domin	S	E	Occasional
<i>P. linearis</i> Andrews	S	E	Occasional
<i>Petrophile pedunculata</i> R. Br.	S	E	Occasional
<i>P. pulchella</i> R. Br.	S	E	*
<i>P. sessilis</i> Sieber ex Schult.	S	E	*
<i>Telopea speciosissima</i> R. Br.	S	E	Occasional
<i>Xylomelum pyriformis</i> Sm.	T	E	Occasional

FABACEAE

1) MIMOSOIDAE

<i>Acacia decurrens</i> Willd.	T	E	Occasional esp. moist gullies/slopes
<i>A. falcata</i> Steud.	S	E	*
<i>A. falciformis</i> DC.	T	E	*
<i>A. floribunda</i> Willd.	S	E	*
<i>A. implexa</i> Benth.	S	E	*
<i>A. linifolia</i> Willd.	S	E	Abundant
<i>A. longifolia</i> (Andrews) Willd.	S	E	Abundant esp. after fire
<i>A. myrtifolia</i> Willd.	S	E	Occasional, ridgetop plateaux
<i>A. parramattensis</i> Tindale	S	E	Very abundant
<i>A. suaveolens</i> (Sm.) Willd.	S	E	Occasional
<i>A. terminalis</i> J.F. MacBr.	S	E	Occasional ridgetop plateaux
<i>A. ulicifolia</i> Court	S	E	Abundant

2) FABOIDAE

<i>Bossiaea buxifolia</i> A.Cunn.	S	E	Rare
<i>B. heterophylla</i> Vent.	S	E	Occasional
<i>B. lenticularis</i> DC.	S	E	*
<i>B. neo-anglica</i> F. Muell.	S	E	*
<i>B. obcordata</i> Druce	S	E	Occasional
<i>B. rhombifolia</i> Sieber ex DC.	S	E	Occasional
<i>Daviesia corymbosa</i> Sm.	S	E	Rare
<i>Desmodium rhytidophyllum</i> F. Muell ex Benth.	S or TW	E	*
<i>D. varians</i> (Labill.) G. Don	TW	E	*
<i>Dillwynia glaberrima</i> Sm.	S	E	*

S. ROSE AND H.A. MARTIN

<i>D. parvifolia</i> R.Br.	S	E	*
<i>D. phyllicoides</i> A. Cunn. sp. complex	S	E	Abundant
<i>Glycine clandestina</i> J.C. Wendl.	TW	E	Abundant
<i>Gompholobium grandiflorum</i> Sm.	S	E	*
<i>G. latifolium</i> Sm.	S	E	*
<i>G. minus</i> Sm.	S	E	Occasional
<i>Hardenbergia violacea</i> (Schneev.) Stearn	C	E	Very abundant
<i>Hovea linearis</i> (Sm.) R. Br.	S	E	Occasional
<i>Indigofera australis</i> Willd.	S	E	Abundant
<i>Kennedia rubicunda</i> Vent.	TW	E, O	Occasional
<i>Mirbelia rubiifolia</i> (Andrews) G. Don	S	E	*
<i>Podolobium ilicifolium</i> (Andrews) Crisp & P.H. Weston.	S	E	Occasional esp. rocky slopes
<i>Pultenaea flexilis</i> Sm.	S	E	Very abundant
<i>P. linophylla</i> Schrad. & J.C. Wendl.	S	E	*
<i>P. villosa</i> Andrews.	S	E	Occasional esp. alluvial fans
<i>Viminaria juncea</i> (Schrad.) Hoffsgg..	S	E	Occasional esp. damp sites

RUTACEAE

<i>Boronia ledifolia</i> (Vent.) J. Gray ex. DC.	S	E	Occasional, esp. rocky slopes
<i>B. polygalifolia</i> Sm.	S	E	*
<i>Eriostemon australasius</i> Pers.	S	E, O	Occasional
<i>E. hispidula</i> . (Spreng.) Paul G. Wilson	S	E, O	Abundant

ERICACEAE

<i>Astroloma humifusum</i> R. Br.	S	E, O	*
<i>Epacris pulchella</i> Cav.	S	E, O	Rare
<i>Leucopogon lanceolatus</i> (Sm.) R. Br. var. <i>lanceolatus</i>	S	E	Abundant
<i>Lissanthe sapida</i> R. Br.	S	E	Rare
<i>L. strigosa</i> R.Br.	S	E	Occasional
<i>Monotoca elliptica</i> R.Br.	S	E	Occasional
<i>M. scoparia</i> R.Br.	S	E	Occasional
<i>Styphelia angustifolia</i> DC.	S	E	*

DILLENIACEAE

<i>Hibbertia aspera</i> DC.	S	E	Very abundant
<i>H. diffusa</i> DC.	S	E	Occasional
<i>H. obstusifolia</i> DC.	S	E	Occasional, moister slopes
<i>H. serpyllifolia</i> DC	S	E	Occasional, moister slopes

GOODENIACEAE

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<i>Cooperhooia barbata</i> (R. Br.) Carolin	S	E	Occasional
<i>Dampiera purpurea</i> R. Br.	S	E	Occasional, moister slopes
<i>Goodenia hederacea</i> Sm.	C	E	Occasional, lake margins
<i>Scaevola ramosissima</i> K. Krause	H	E	Occasional
CASUARINACEAE			
<i>Allocasuarina littoralis</i> (Salisb.) L. Johson	T	A	Very abundant, lake margins, footslopes
<i>A. torulosa</i> (Aiton) L. Johnson	T	A	Occasional, upper slopes, ridgetops
EUPHORBIACEAE			
<i>Amperea xiphoclada</i> (Spreng.) Druce	S	E	Occasional
<i>Breynia oblongifolia</i> Muell. Arg.	S	E	*
<i>Phyllanthus gasstroemii</i> Muell. Arg.	S	E	Abundant
<i>P. occidentalis</i> J.T. Hunter & J.J. Bruhl	S	E	Abundant
<i>Poranthera ericifolia</i> Rudge	S	E	*
<i>P. microphylla</i> Brongn.	H	E	*
RUBIACEAE			
<i>Galium binifolium</i> N.A. Wakefield	H	A	*
<i>G. propinquum</i> A. Cunn.	H	A	*
<i>Opercularia aspera</i> Gaertn.	H	A	Abundant on lake margin, moist areas
<i>O. diphylla</i> Gaertn.	H	A	*
<i>O. varia</i> Hook. f.	H	A	Abundant on lake margin, moist areas
<i>Pomax umbellata</i> Benth.	H or S	A	Very abundant
APIACEAE			
<i>Actinotus helianthi</i> Labill.	H	E	Occasional
<i>Centella asiatica</i> Urb.	C	E	*
<i>Hydrocotyle acutiloba</i> N.A. Wakefield	H	A, E	*
<i>H. laxiflora</i> DC.	H	A, E	*
<i>H. peduncularis</i> A. Rich.	H	A, E	*
<i>Platysace linearifolia</i> C. Norman	S	E	Abundant.
LAURACEAE			
<i>Cassytha glabella</i> R. Br.	TW		*
<i>C. pubescens</i> R. Br.	TW		*
<i>Cinnamomum camphora</i> +T. Nees & C.H. Eberm	T	A, E	One specimen observed
RANUNCULACEAE			
<i>Clematis aristata</i> R. Br. ex Ker Gawl.	TW	E	*
VIOLACEAE			
<i>Hybanthus monopetalum</i> (Schultes) Domin.	H	E	*
<i>Viola betonicifolia</i> Sm.	H	E	Occasional, moist areas

<i>V. hederacea</i> Labill.	H	E	Occasional, moist areas
CRASSULACEAE			
<i>Crassula sieberiana</i> (Schultes & Schultes. f.) Druce	H	E	*
DROSERACEAE			
<i>Drosera spathulata</i> Labill.	H	E	Occasional, damp places
POLYGONACEAE			
<i>Persicaria hydropiper</i> (L.) Spach.	H	E	*
<i>Acetosella vulgaris</i> Fourr.	H	E	Occasional, moist sites
OXALIDACEAE			
<i>Oxalis corniculata</i> + L.	H	E	Occasional, esp. disturbed sites
GERANIACEAE			
<i>Geranium homeanum</i> Turcz.	H	E	*
HALORAGACEAE			
<i>Gonocarpus micranthus</i> Thunb.	C	E	Occasional esp. near lake margins
<i>G. tetragynus</i> Labill.	H	E	Occasional, moist places
<i>Myriophyllum variifolium</i> Hook. f..	Aq H	A	*
THYMELEACEAE			
<i>Pimelea linifolia</i> Sm.	S	E, S	Very abundant
PITTOSPORACEAE			
<i>Billardiera scandens</i> Sm.	TW	E	Occasional, shady slopes
<i>Bursaria spinosa</i> Cav.	S	E	Occasional
PASSIFLORACEAE			
<i>Passiflora edulis</i> + Sims	TW	E	One specimen observed
HYPERICACEAE			
<i>Hypericum gramineum</i> G. Forst.	H	E	*
ELAEOCARPACEAE			
<i>Elaeocarpus reticulatus</i> Sm.	T	E	Occasional, only moist gullies
<i>Tetratheca thymifolia</i> Sm.	S	E	Rare
MALVACEAE			
<i>Sida rhombifolia</i> + L.	S	E	*
CUNONIACEAE			
<i>Ceratopetalum gummiferum</i> Sm.	T	E	Occasional, only moist gullies
ROSACEAE			
<i>Rubus parvifolius</i> L.	S	E	*
<i>R. fruticosus</i> + species complex	S	E	Rare, disturbed sites
STACKHOUSIACEAE			
<i>Stackhousia monogyna</i> Labill.	H	E	*

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<i>S. viminea</i> Sm.	H	E	*
LORANTHACEAE			
Unidentified	S	O	Rare, host <i>Eucalyptus</i> spp.
SANTALACEAE			
<i>Exocarpos cupressiformis</i> Labill.	T	A, E	Occasional
<i>E. strictus</i> R. Br.	T	A, E	Rare, moist gullies
<i>Leptomeria acida</i> R. Br.	S	A, E	Rare
SAPINDACEAE			
<i>Dodonaea triquetra</i> Benth.	T	E	Occasional, moist slopes
LOGANIACEAE			
<i>Mitrasacme polymorpha</i> R. Br.	S	E	Occasional
APOCYNACEAE			
<i>Parsonsia straminea</i> F. Muell.	TW	E	Rare
<i>Marsdenia flavescens</i> A. Cunn.	TW	E	Rare, moist, shaded positions
<i>M. suaveolens</i> R. Br.	TW	E	Occasional, esp. shaded slopes
<i>Tylophora barbata</i> R. Br.	TW	E	*
MENYANTHACEAE			
<i>Villarsia exaltata</i> G. Don	H	H, E	* near water
CAPRIFOLIACEAE			
<i>Lonicara japonica</i> + Thunb. ex Murray	TW	E	*
PLANTAGINACEAE			
<i>Plantago lanceolata</i> + L.	H	A, E	Occasional esp. disturbed sites
CAMPANULACEAE			
<i>Wahlenbergia graniticola</i> Carolin	H	E	Occasional
<i>W. stricta</i> (R. Br.) Sweet	H	E	*
<i>W. communis</i> Carolin	H	E	*
LOBELIACEAE			
<i>Isotoma axillaris</i> Lindl.			*
<i>Pratia purpurascens</i> (R. Br.)F. Wimmer.	C	E	Occasional esp. moist sites
STYLIDIACEAE			
<i>Stylidium graminifolium</i> Willd.	H	E	Occasional esp. open sunny sites
<i>S. laricifolium</i> Rich.	H.	E	*
<i>S. lineare</i> Sw. ex Willd.	H	E	*
ASTERACEAE			
<i>Bidens pilosa</i> + L.	H	A, E	
<i>Brachycome aculeata</i> R. Br.	H	A, E	*
<i>B. angustifolia</i> Cunn. ex DC.	H	A, E	abundant

<i>Cassinia aculeata</i> R. Br.	S	A, E	Occasional, shady slopes
<i>C. aureonitens</i> N.A. Wakefield	S	A, E	*
<i>C. longifolia</i> R. Br.	S	A, E	Occasional, shady slopes
<i>C. quinquefaria</i> R. Br.	S	A, E	*
<i>Conzya albida</i> + Willd. ex Sprengel	H	A, E	Weed on disturbed sites
<i>C. parva</i> + Cronq.	H	A, E	Weed on disturbed sites
<i>Coreopsis lanceolata</i> + L.	H	A, E	*
<i>Facelis retusa</i> + Sch. Bip.	H	A, E	*
<i>Gnaphalium gymnocephalum</i> DC.	H.	A, E	*
<i>Helichrysum elatum</i> DC.	H or S	A, E	Occasional esp. gullies, very moist slopes
<i>H. scorpiodes</i> Labill.	H	A, E	Occasional
<i>Hypochaeris radicata</i> + L.	H	A, E	Abundant esp. moist disturbed sites
<i>Lagenophora stipitata</i> (Labill.) Druce	H	A, E	Shady slopes
<i>Olearia microphylla</i> Maiden & Betche	S	A, E	Occasional, mostly shady slopes
<i>O. viscidula</i> Benth.	S	A, E	*
<i>Ozonthamnus adnatus</i> DC..	S	A, E	*
<i>O. diosmifolium</i> (Vent.) DC	S	A, E	*
<i>Podolepis jaceoides</i> Voss	H	A, E	Occasional
<i>Pseudognaphalium. luteoalbum</i> + (L.) Hillard & B.L. Burtt	H	A, E	Occasional
<i>Senecio lautus</i> + G. Forst. ex Willd.	H	A, E	Weed, on disturbed ground
<i>S. linearifolius</i> A. Rich.	H	A, E	*
<i>S. quadridentatus</i> Labill.	H	A, E	Weed, on disturbed ground
<i>S. velleioides</i> A. Cunn. ex DC.	H	A, E	*
<i>Sigesbeckia orientalis</i> L.	H	A, E	*
SOLANACEAE			
<i>Solanum pungetium</i> R. Br.	H	E	Occasional, esp. moist areas
CONVOLVULACEAE			
<i>Dichondria repens</i> J.R. Forst. & G Forst	C	E	Occasional esp. lake margins
<i>Polymeria calycina</i> R. Br.	C	E	*
SCROPHULARIACEAE			
<i>Veronica plebeia</i> R. Br.	H	E	*
LENTIBULARIACEAE			
<i>Utricularia australis</i> R. Br.	aqH	E	Rare, floating on open water > 2m deep
ACANTHACEAE			
<i>Brunoniella pumilio</i> (R. Br.) Bremek.	H	E	*
VERBENECEAE			
<i>Verbenea bonariensis</i> L.	H	E	Occasional, disturbed sites

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LAMIACEAE

<i>Ajuga australis</i> R.Br.	H	E	*
<i>Scutellaria humilis</i> R. Br.	H	E	*

POTAMOGETONACEAE

<i>Potamogeton tricarinatus</i> A. Benn.	aqH	a	*
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XYRIDACEAE

<i>Xyris complanata</i> R. Br.	H	E	Rare in damp places
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ANTHERICACEAE

<i>Arthropodium milleflorum</i> (DC.) J.F. Macbr.	H	E	*
<i>Laxmannia gracilis</i> R. Br.	H	E	*
<i>Tricoryne simplex</i> R. Br.	H	E	*

PHORMIACEAE

<i>Dianella caerulea</i> Sims	H	E	Occasional
<i>D. revoluta</i> R. Br.	H	E	*
<i>Stypandra glauca</i> R. Br.	H	E	Occasional, only northern end of park
<i>Thelionema caespitosum</i> (R. Br.) R.J.F. Hend.	H	E	Occasional

SMILACACEAE

<i>Smilax glycyphylla</i> Sm.	TW	?	Occasional, moist slopes
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LUZURIAGACEAE

<i>Eustrephus latifolius</i> Ker Gawl.	TW	E	Occasional, moist slopes
<i>Geitonoplesium cymosum</i> R. Br.	TW	E	Rare, moist slopes only

IRIDACEAE

<i>Patersonia glabrata</i> R. Br.	H	E	*
<i>P. sericea</i> R. Br.	H	E	*

LOMANDRACEAE

<i>Lomandra confertifolia</i> (F.M. Bailey) Fahn ssp. <i>rubiginosa</i> R.T. Lee	H	E	Occasional
<i>L. cylindrica</i> R.T. Lee	H	E	Occasional
<i>L. filiformis</i> (Thunb.) J. Britten	H	E	*
<i>L. glauca</i> Ewart	H	E	*
<i>L. gracilis</i> R.T. Lee	H	E	Occasional
<i>L. longifolia</i> Labill.	H	E	Abundant esp. footslopes
<i>L. multiflora</i> (R. Br.) J. Britten	H	E	Rare
<i>L. obliqua</i> J.R. Macbr.	H	E	Abundant

XANTHORRHOEACEAE

<i>Xanthorrhoea</i> sp.	S	E	Occasional along ridgetop plateaux
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HAEMODORACEAE

<i>Haemodorum planifolium</i> R. Br.	H	E	*
PHILYDRACEAE			
<i>Philydrum lanuginosum</i> Banks & Sol. ex Gaertn.	aqH	E	*
ORCHIDACEAE			
<i>Acianthus caudatus</i> R. Br.	H	E	Occasional, moist slopes
<i>A. exsertus</i> R. Br.	H	E	*
<i>A. fornicatus</i> R. Br.	H	E	Occasional, moist slopes
<i>Chiloglottis formicifera</i> FitzG.	H	E	Occasional, only moist places
<i>C. reflexa</i> Druce	H	E	*
<i>Corybas aconitiflorus</i> K.D. Koenig & Sims	H	E	*
<i>Dendrobium speciosum</i> Sm.	epH	E	Occasional, shady rock outcrops
<i>Diuris maculata</i> Sm.	H	E	*
<i>Liparis reflexa</i> (R. Br) Lindl.	H	E	*
<i>Microtis unifloia</i> (Forst. f.) Reichb. f	H	E,S	*
<i>Pterostylis</i> sp.	H	E	*
JUNCACEAE			
<i>Juncus articulatus</i> + L.	H	A	*
<i>Juncus continuus</i> L.A.S. Johnson	H	A	*
<i>J. planifolius</i> R. Br.	H	A	*
<i>J. prismatocarpus</i> R. Br.	H	A	*
RESTIONACEAE			
<i>Baloskion gracilis</i> (R. Br.) B.G. Briggs & L.A.S. Johnson	H	A	Occasional, lake margins
<i>Empodisma minus</i> (Hook.f.) L.A.S. Johnson & D.F. Cutler	H	A	Occasional, lake margins
<i>Lepyrodia mulleri</i> Benth.	H	A	*
<i>L. scariosa</i> R. Br.	H	A	*
CYPERACEAE			
<i>Baumea arthrophylla</i> (Nees) Broeck.	H	A	*
<i>B. teretifolia</i> Palla	H	A, E	*
<i>Baumea</i> sp. nov.	H	A, E	*
<i>Bolboschoenu fluviatilis</i> (Torrey) Soják	H	A, E	*
<i>Caustis flexuosa</i> R. Br.	H	A, E	Occasional, rocky slopes, plateau tops
<i>Cyperus laevis</i> R. Br.	H	A, E	Occasional, moist sites
<i>Eleocharis atricha</i> R. Br	H	A, E	Occasioal
<i>E. sphacelata</i> R. Br	aqH	A, E	Abundant, in open water
<i>Isolepis inundatus</i> Hook. f.	H	A, E	*

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<i>Lepidosperma laterale</i> R. Br	H	A, E	Occasional
<i>L. longitudinale</i> Labill.	H	A, E	Abundant, margins of lakes
<i>Lepironia articulata</i> Domin.	aqH	A, E	Very abundant, mostly open water
<i>Schoenus brevifolius</i> R. Br	H	A, E	Occasional, lake margins
<i>S. melanonstachys</i> R. Br	H	A, E	Occasional, lake martins
<i>S. villosus</i> R. Br	H	A, E	*
CABOMBACEAE			
<i>Brasenia schreberi</i> Gmelin	aqH	E	Occasional, open water only
POACEAE			
<i>Anisopogon avenaceus</i> R. Br	H	A	*
<i>Aristida ramosa</i> R. Br	H	A	Occasional
<i>A. vagans</i> Cav	H	A	*
<i>Austrostipa rudis</i> Spreng. ssp. <i>nervosa</i> (J. Vickery) J. Everett & S.W.L. Jacobs	H	A	*
<i>Briza maxima</i> + L.	H	A	*
<i>Cymopogon refractus</i> (R. Br) A. Camus	H	A	*
<i>Dichelachne rara</i> (R. Br) J. Vickery	H	A	*
<i>Digitaria ramularis</i> (Trin.) Henrad.	H	A	Occasional esp. footslopes
<i>Echinopogon caespitosus</i> + C.E. Hubb.	H	A	*
<i>E. ovatus</i> + (G. Forst.) P. Beauv.	H.	A	Occasional esp. open areas
<i>Entolasia marginata</i> (R. Br) Hughs	H	A	*
<i>E. stricta</i> (R. Br) Hughs	H	A	*
<i>Eragrostis leptostachya</i> Steud.	H	A	*
<i>Imperata cylindrica</i> P. Beauv. var. <i>major</i> (Nees) C.E. Hubb.	H	A	Abundant esp. after burning
<i>Microlaena stipoides</i> (Labill.) R. Br	H	A	*
<i>Panicum simile</i> Domin	H	A	*
<i>Paspalidium gracile</i> (R. Br.) Hughes	H	A	*
<i>Paspalum dilatatum</i> + Poir.	H	A	Occasional esp. disturbed footslopes
<i>Pseudoraphis paradoxa</i> (R. Br.) Pilger	H	A	*
<i>Setaria gracilis</i> + Kunth.	H	A	Occasional
<i>S. pubescens</i> R. Br.	H	A	*
<i>Themeda australis</i> (R.Br.) Stapf.	H	A	Abundant
FERNS/FERN ALLIES			
SELAGINELLACEAE			
<i>Selaginela uliginosa</i> (Labill.) Spring			Occasional, damp places
OPHIOGLOSSACEAE			
<i>Botrychium australe</i> R.Br.			*

DICKSONIACEAE

Calochlaena dubia (R.Br.) M. Turner
& R. White Only in very moist gullies

CYATHACEAE

Cyathea sp. Rare, moist gullies

DENNSTAEDTIACEAE

Hypolepis muelleri N.A. Wakef. Occasional, moist creek banks

Pteridium esculentum (Forst f.)
Cockayne Abundant, esp. disturbed areas

LINDSAEACEAE

Lindsaea microphylla Sw. Rare, moist gullies

ADIANTACEAE

Adiantum aethiopicum L. Occasional, moist gullies

A. hispidulum Sw. *

SINOPTERIDACEAE

Cheilanthes distans (R.Br.) Mett. *

C. austrotenuifolia Quirk & Chambers Occasional, esp. rock outcrops

DAVALLIACEAE

Davallia pyxidata Cav. Rare, on rockfaces in moist areas

BLECHNACEAE

Blechnum cartilagineum Sw. abundant, rocky, shaded slopes

Doodia aspera R.Br. Occasional, moist slopes

APPENDIX 1B

The species in the gully forest (site TS 6, Fig. 1).

Species	Family	Presence outside gully
Trees, 10-30 m		
<i>Eucalyptus deanei</i> Maiden	Myrtaceae	-
<i>E. elata</i> Dehnh.	"	-
<i>E. piperita</i> Sm.	"	+
Small trees and shrubs < 10 m		
<i>Doryphora sassafras</i> Endl.	Monimiaceae	-
<i>Grevillea mucronata</i> R. Br.	Proteaceae	+
<i>Hakea salicifolia</i> (Vent.) B.L. Burt.	"	-
<i>Lomatia silaifolia</i> (Sm.) R. Br	"	+
<i>Persoonia levis</i> (Cav.) Domin.	"	+
<i>P. linearis</i> Andrews.	"	+

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<i>P. mollis</i> R. Br.	“	-
<i>Stenocarpus salignus</i> R. Br.	“	-
<i>Pittosporum revolutum</i> Dryand.	Pittosporaceae	-
<i>Elaeocarpus reticulatus</i> Sm.	Elaeocarpaceae	+
<i>Lasiopetalum ferrugineum</i> Sm. var. <i>ferrugineum</i>	Sterculiaceae	-
<i>Bertya pomaderriodes</i> F. Muell.	Euphorbiaceae	-
<i>Callicoma serratifolia</i> Andrews	Cunoniaceae	-
<i>Ceratopetalum apetalum</i> D. Don	“	-
<i>C. gummiferum</i> Sm.	“	+
<i>Acacia decurrens</i> Willd.	Fabaceae	-
<i>A. elata</i> Benth.	“	-
<i>A. parramattensis</i> Tindale	“	+
<i>Pultenaea flexilis</i> Sm.	“	+
<i>Acmema smithii</i> (Poir.) Merr. & Perry	Myrtaceae	-
<i>Backhousia myrtifolia</i> Hook. f. & Harv.	“	-
<i>Tristaniopsis</i> sp aff. <i>laurina</i> (smith) Peter G. Wilson & Waterhouse	“	+
<i>Leptospermum trinervium</i> (Sm.) J. Thompson	“	+
<i>Allocasuarina torulosa</i> (Aiton) L. Johnson	Casuarinaceae	+
<i>Pomaderris intermedia</i> Sieber	Rhamnaceae	-
<i>Pomaderris</i> sp. unidentified	“	-
<i>Exocarpos strictus</i> R. Br.	Santalaceae	-
<i>Correa reflexa</i> Vent. var. <i>reflexa</i>	Rutaceae	-
<i>Nematolepis squameum</i> (Labill.) Eng.	“	-
<i>Dodonaea triquetra</i> J.C. Wendl.	Sapindaceae	+
<i>Astrotricha latifolia</i> Benth.	Aralaceae	+
<i>Dracophyllum secundum</i> R. Br.	Ericaceae	-
<i>Leucopogon lanceolatus</i> (Sm.) R. Br. var. <i>lanceolatus</i>	“	+
<i>Logania albiflora</i> Druce	Loganiaceae	-
<i>Notelea</i> sp. unidentified	Oleaceae	-
<i>Rapanea variabilis</i> Mez.	Myrsinaceae	-
<i>Dampiera purpurea</i> R. Br.	Goodeniaceae	+
<i>Cassinia aculeata</i> R. Br.	Asteraceae	+
Ground cover, herbs and shrubs < 1 m		
<i>Viola bentonicifolia</i> Sm.	Violaceae	+
<i>Drosera auriculata</i> Backh. ex Planch.	Droseraceae	+
<i>Solanum</i> sp. unidentified	Solonaceae	+
<i>Corybas frimbriatus</i> (R. Br.) Rchb. f.	Orchidaceae	+

<i>Gahnia</i> sp unidentified	Cyperaceae	-
<i>Hibbertia obtusifolia</i> DC.	Dilleniaceae	+
Climbers		
<i>Cassytha glabella</i> R. Br.	Cassythaceae	-
<i>Sarcopetalum harveyanum</i> F. Muell.	Menispermaceae	-
<i>Smilax australis</i> R. Br.	Smilacaceae	+
<i>Cissus antarctica</i> Vent.	Vitaceae	-
<i>Eustrephus latifolius</i> Ker Gawler	Luzuriagaceae	+
<i>Geitonoplesium cymosum</i> R. Br.	"	+
Pachycauls		
<i>Cyathea australis</i> (R. Br.) Domin.	Cyatheaceae	-
Ground ferns		
<i>Todea barbara</i> (L.) T. Moore	Osmundaceae	-
<i>Gleichenia microphylla</i> R. Br.	Gleicheniaceae	-
<i>Sticherus</i> sp.	"	-
<i>Hymenophyllum cupressiforme</i> Labill.	Hymenophyllaceae	-
<i>Calochlaena dubia</i> (R. Br.) M. Turner	Cyatheaceae	-
<i>Pteridium esculentum</i> (Forst.f.) Cockayne	Dennstaediaceae	+
<i>Adiantum aethopicum</i> L.	Adiantaceae	+
<i>Cheilanthes austrotenuifolia</i> Quirk & Chambers	Sinopteridaceae	+
<i>Pyrrosia rupestris</i> (R. Br.) Ching	Polypodiaceae	-
<i>Asplenium flabellifolium</i> Cav.	Aspleniaceae	-
<i>Blechnum cartilagineum</i> Sw.	Blechnaceae	+
<i>B. nudum</i> (Labill.) Mett. ex Luerssen.	"	-
<i>Doodia aspera</i> R. Br.	"	+

APPENDIX 2

The identification of pollen of the family Myrtaceae.

Fig. 14 illustrates the pollen characters used and Table 3 presents the distribution of these characters amongst the species. These morphological characters were insufficient to reliably identify species but they have been used to place the species in distinctive groups which are defined thus:

Angophora/Corymbia group: Large-sized grains, 26 (30-40) 45 μm (mean in brackets), with x (rarely w) type pore and a thick exine, 2-4 μm .

Eucalyptus group: Medium-sized grains, 18 (21-25) 28 μm , with x (rarely w) type pore and medium-thickness exine, 1.5-3.0 μm .

Melaleuca/Leptospermum group: Small sized grains, 10 (13-19) 23 μm , with only y and z type pore and thin exine, <1-1 μm .

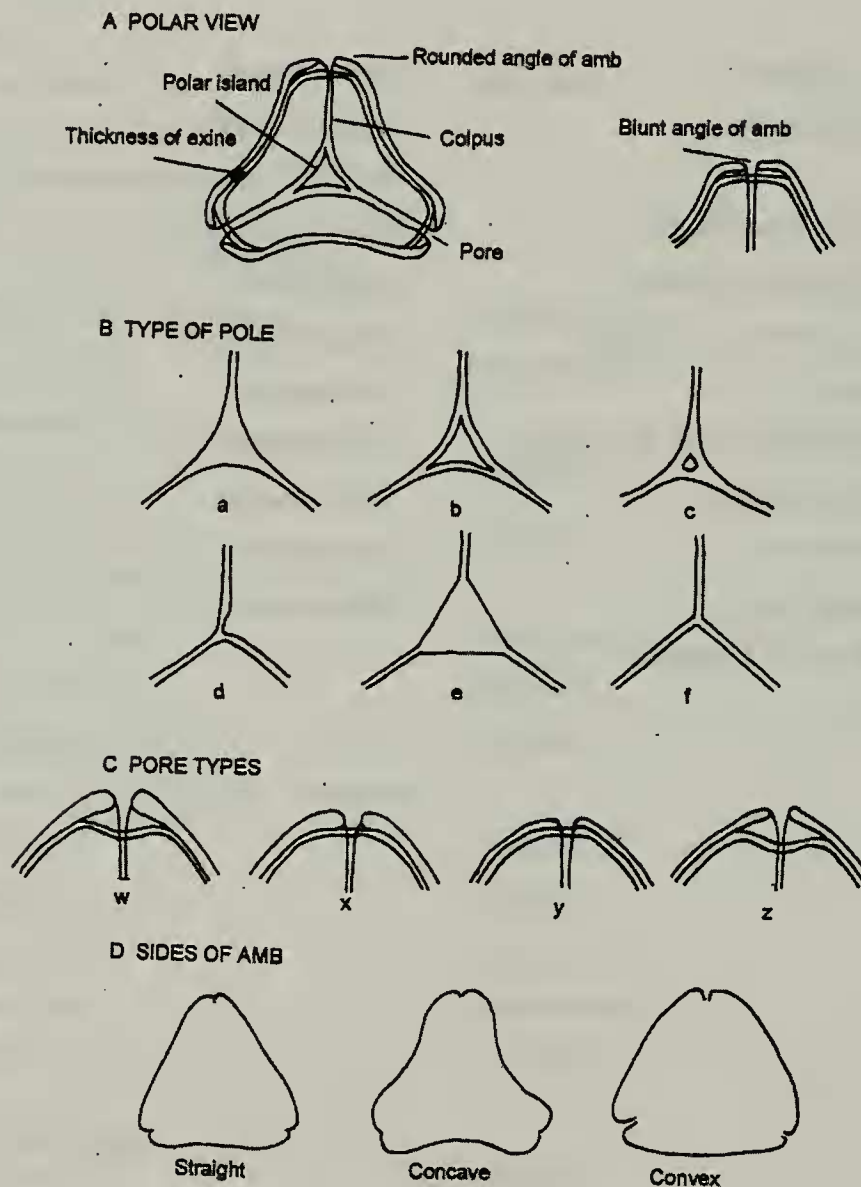


Figure 14. The morphological characters used to identify pollen grains of Myrtaceae

Table 3. Pollen morphological characters used to identify myrtaceous pollen groups. () infrequent occurrence.

Species	Equatorial diameter		Type of pole	Type of pore	Amb angle	Amb sides	Exine pattern	Exine thickness (µm)
	Mean (µm)	Range						
<i>Angophora/Corymbia</i> pollen group								
<i>Angophora floribunda</i>	30±1.7	(26-33)	f (e) a	x (w)	round	straight	faint	2-3
<i>Corymbia eximia</i>	40.7±2.8	(35-45)	a, c (f)	x	round	straight	-	2-4
<i>C. gummifera</i>	40.0±3.0	(33-45)	b, a (f)	x	round	convex	-	2.5
<i>Eucalyptus</i> pollen group								
<i>Eucalyptus punctata</i>	23.8±1.3	(18-27)	a	w (x)	round	straight & concave	-	1.5-2
<i>E. piperita</i>	21.0±1.3	(18-24)	a	x	round	straight & concave	-	
<i>E. tereticornis</i>	23.4±1.3		a	x	round	straight	-	1.5-2
<i>E. globoidea</i>	24.8±2.0	(20-28)	a	x (w)	round	straight & concave	-	1.5-3
<i>Melaleuca/Leptospermum</i> pollen group								
<i>Melaleuca thymoides</i>	19.6±1.4	(18-23)	f (a)	z	round	concave	-	to 1
<i>M. linariifolia</i>	15.4±1.4	(13-18)	f	z	round	concave	-	to 1
<i>Leptospermum juniperinum</i>	13.0±1.8	(10-19)	f	z	round	concave	-	to 1
<i>L. trinervium</i>	13.5±1.4	(12-16)	f	y	blunt	straight	coarse, granular	to 1
<i>Tristaniopsis</i> sp. aff <i>laurina</i>	14.4±1.1	(12-17)	a	z	blunt	straight & concave	-	to 1
<i>Acmena smithii</i>	14		f	-	round	straight & concave	-	to 1
<i>Backhousia myrtifolia</i>	18.0	(14-21)	f	z	round	concave	faint	<1

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APPENDIX 3

Pollen type name on pollen diagrams and probable source in the vegetation. For full lists of species in each genus, see Appendix 1A

Pollen type	Probable source in present day vegetation
Pollen types found on both surface sample and fossil pollen diagrams.	
<i>Eucalyptus</i>	<i>Eucalyptus</i> spp.
<i>Angophora/Corymbia</i>	<i>A. floribunda</i> , <i>C. eximia</i> , <i>C. gummifera</i>
Melaleuca/Leptospermum	<i>Melaleuca</i> spp. and <i>Leptospermum</i> spp., <i>Acmena smithii</i> , <i>Tristaniopsis</i> sp., <i>Backhousia myrtifolia</i> .
Myrtaceae	Any other species in the family
<i>Allocasuarina</i>	<i>A. torulosa</i> , <i>A. littoralis</i>
<i>Pinus</i>	<i>Pinus</i> spp., most likely <i>P. radiata</i>
Cupressaceae	Native <i>Callitris</i> or other introduced species
<i>Dodonaea</i>	<i>Dodonaea triquetra</i>
Proteaceae	All species in the family, excluding <i>Banksia</i> spp.
<i>Banksia</i>	<i>Banksia</i> spp.
<i>Monotoca</i>	<i>Monotoca</i> spp.
Tricolporates	Includes species from Fabaceae (excluding <i>Acacia</i>), Rutaceae, Dilleniaceae, <i>Goodenia hederaceae</i> , <i>Ampera xyphoclada</i> , Violaceae, <i>Bursaria spinosa</i> , Stylidiaceae
Tricolporate 2 (15 um grains)	Mainly <i>Elaeocarpus reticulatus</i> , <i>Ceratopetalum</i> spp.
<i>Pimelea</i>	<i>Pimelea linifolia</i>
<i>Acacia</i>	<i>Acacia</i> spp.
Poaceae	Poaceae species
<i>Plantago</i> cf <i>lanceolata</i>	<i>Plantago lanceolata</i> (introduced)
<i>Plantago</i> cf <i>varia</i>	<i>Plantago varia</i> (native)
Chenopodiaceae	Chenopodiaceae species (not in Appendix 1) probably herbs
Caryophyllaceae	Caryophyllaceae, as above
Brassicaceae	Brassicaceae, as above
Asteraceae Tubuliflorae	Asteraceae species, excluding <i>Hypochoeris radicata</i>
Asteraceae Liguliflorae	Probably only <i>Hypochoeris radicata</i>
Zygophyllaceae	Probably <i>Tribulus terrestris</i> , but the plant was not observed
Polygonaceae	<i>Persicaria decipiens</i> , <i>P. hydropiper</i> , <i>P. orientale</i>
<i>Gonocarpus</i>	<i>Gonocarpus</i> spp.
Trilete spores	<i>Cyathea</i> sp, <i>Pteridium</i> sp. <i>Adiantum</i> spp. <i>Cheilanthes</i> spp.
Monolete spores	<i>Blechnum</i> spp., <i>Davallia</i> sp., <i>Doodia</i> sp.
<i>Sellaginella</i>	<i>Sellaginella uliginosa</i>
<i>Hydrocotyle</i>	<i>Hydrocotyle</i> spp.

Restionaceae	Restionaceae species
Cyperaceae	Cyperaceae species
<i>Myriophyllum</i>	<i>Myriophyllum variifolium</i>
<i>Potamogeton</i>	<i>Potamogeton tricarinatus</i>
Unknown 1 (inaperturate)	Inaperturate grain with coarse granular pattern, thin exine, 20-25 um diameter.
Unknowns	All other unidentified grains

Other pollen types on surface sample pollen diagram

<i>Platysace</i>	<i>Platysace linearifolia</i>
<i>Leucopogon</i>	<i>Leucopogon</i> spp
Monosulcate	Liliaceae (sensu. lat.)
<i>Exocarpus</i>	<i>Exocarpus</i> spp.
Goodeniaceae	<i>Scaveola ramossisima</i>
Apocynaceae	<i>Parsonsia straminea</i>
Portulacaceae	<i>Portulaca oleracea</i>
Loranthaceae	Mistletoe on <i>Eucalyptus</i> spp.
<i>Lomandra</i>	<i>Lomandra</i> spp